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VOLUME 48 SEPTEMBER 1948 NUMBER 3

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STAPES, FISSULA ANTE FENESTRAM AND ASSOCIATED STRUCTURES IN MAN

V. From the Fetus of 160 Mm. (Five Months) to Newborn Infant

BARRY J. ANSON, Ph.D. (Med. Sc.)
AND
EARL W. CAULDWELL, M.D.
CHICAGO

IN CONTINUATION of an investigation into the developmental and adult anatomy of the auditory ossicles, of the otic capsule and of the extracapsular portion of the temporal bone, attention has been focused on the stapes, the vestibular (oval) window and the anteriorly situated fissular tract, which regularly opens into the fenestra. Two introductory articles in the series dealt with the general features of stapedial and fissular morphogenesis [1]; in more recent articles, through a study of more than 200 otologic series of graded age levels, details were supplied to account for the steps in development from the stage of primordial appearance in cartilage to the assumption of adult form and dimensions.[2]

From a selected set of 75 specimens thirty-two crucial stages were especially studied as the basis for the present contribution; of these twenty-one are represented in the illustrations.

MATERIAL AND METHODS

All of the series described and the figures presented in this paper are contained in the otologic collection at the University of Wisconsin. The order of presentation

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Contribution no. 506 from the Anatomical Laboratory of Northwestern University Medical School.

Dr. T. H. Bast, of the Department of Anatomy of the University of Wisconsin, gave us permission to study his excellent series of temporal bones.

This investigation was conducted under the auspices of the Central Bureau of Research of the American Otological Society. During the course of this study, Dr. Cauldwell served on a fellowship endowed by the late Dr. George J. Dennis and, subsequently, by Mrs. Dennis.

1. Anson, B. J.; Karabin, J. E., and Martin, J.; Stapes, Fissula Ante Fenestram and Associated Structures in Man: I. From Embryo of Seven Weeks to That of Twenty-One Weeks, Arch. Otolaryng. **28**:676-697 (Nov.) 1938; II. From Fetus at Term to Adult of Seventy, ibid. **29**:939-973 (June) 1939.

2. Cauldwell, E. W., and Anson, B. J.: Stapes, Fissula Ante Fenestram and Associated Structures in Man: III. From Embryos 6.7 to 50 Mm. in Length, ibid. **36**:891-925 (Dec.) 1942. Anson, B. J., and Cauldwell, E. W.: Stapes, Fissula Ante Fenestram and Associated Structures in Man: IV. From Fetuses 75 to 150 Mm. in Length, ibid. **37**:650-671 (May) 1943.

of the observations follows the graded increase in recorded fetal length. However, since crown-rump length does not provide an accurate indication of ossicular and capsular development, the statements made in the concluding division of the paper are arranged in the order of the successive steps in morphogenetic advance.

Reconstructions of the stapes, of surrounding capsular structures and of adjacent fissular anatomy were prepared by the wax plate method. Comparable, or additional, anatomic features in intermediate stages are demonstrated by drawings and photomicrographs of selected sections. All reconstructions were prepared at a magnification of 125 diameters by the wax plate method from tracings made with an Edinger projection apparatus. Each reconstruction originally included not only the stapes but also the capsular wall of the vestibular window and the adjacent fissula ante fenestram. For several of the figures, these reconstructions were dismantled or cut in order that either the form or the topographic relationships could be more advantageously recorded.

The semidiagrammatic drawings were prepared from Edinger tracings, at a magnification of 50 diameters, from sections similar to those shown in the two introductory plates of photomicrographs (original magnification, 65 diameters).

The following stages are illustrated by photomicrographs:

Length, Mm.	Wisconsin Series No.	Figure No.
167	105	1*a* (See fig. 3*a* to *c*, from same series)
175	104	1*b* (See fig. 4*a* and *b*)
160	41	1*c* (See figs. 5*a* to *c*, 9*a* and *b*, 10*a* and *b*)
170	131	1*d* (See fig. 5*d* to *f*)
210	51	1*e* (See figs. 2*b*, 7*a*, 8*b*, 13*a* and *b*)
290	59	1*f* (See fig. 8*c*)
202	70	2*a* (See fig. 6*b*)
210	51	2*b* (See figs. 1*e*, 7*a*, 8*b*, 13*a* and *b*)

The following stages are illustrated by semidiagrammatic line drawings of sections:

Length, Mm.	Wisconsin Series No.	Figure No.
167	105	3*a* to *c* (See fig. 1*a*, from same series)
163	33	3*d*
175	104	4*a* and *b* (See fig. 1*b*)
160	41	5*a* to *c* (See figs. 1*c*, 9*a* and *b*, 10*a* and *b*)
170	131	5*d* to *f* (See fig. 1*d*)
190	29A	6*a*
202	70	6*b* (See fig. 2*a*)
205	129	6*c*
215	62	6*d*
210	51	7*a* (See figs. 1*e*, 2*b*, 8*b*, 13*a* and *b*)
222	46	7*b*

275	4	7*c* (See fig. 15*a* to *c*)
290	59	7*d*
345	61	7*a* (see fig. 8*d*)
205	129	8*a*
210	51	8*b* (see figs. 1*e*, 2*b*)
290	59	8*c* (See fig. 1*f*)
345	61	8*d* (See fig. 7*e*)
Newborn	315	8*e*

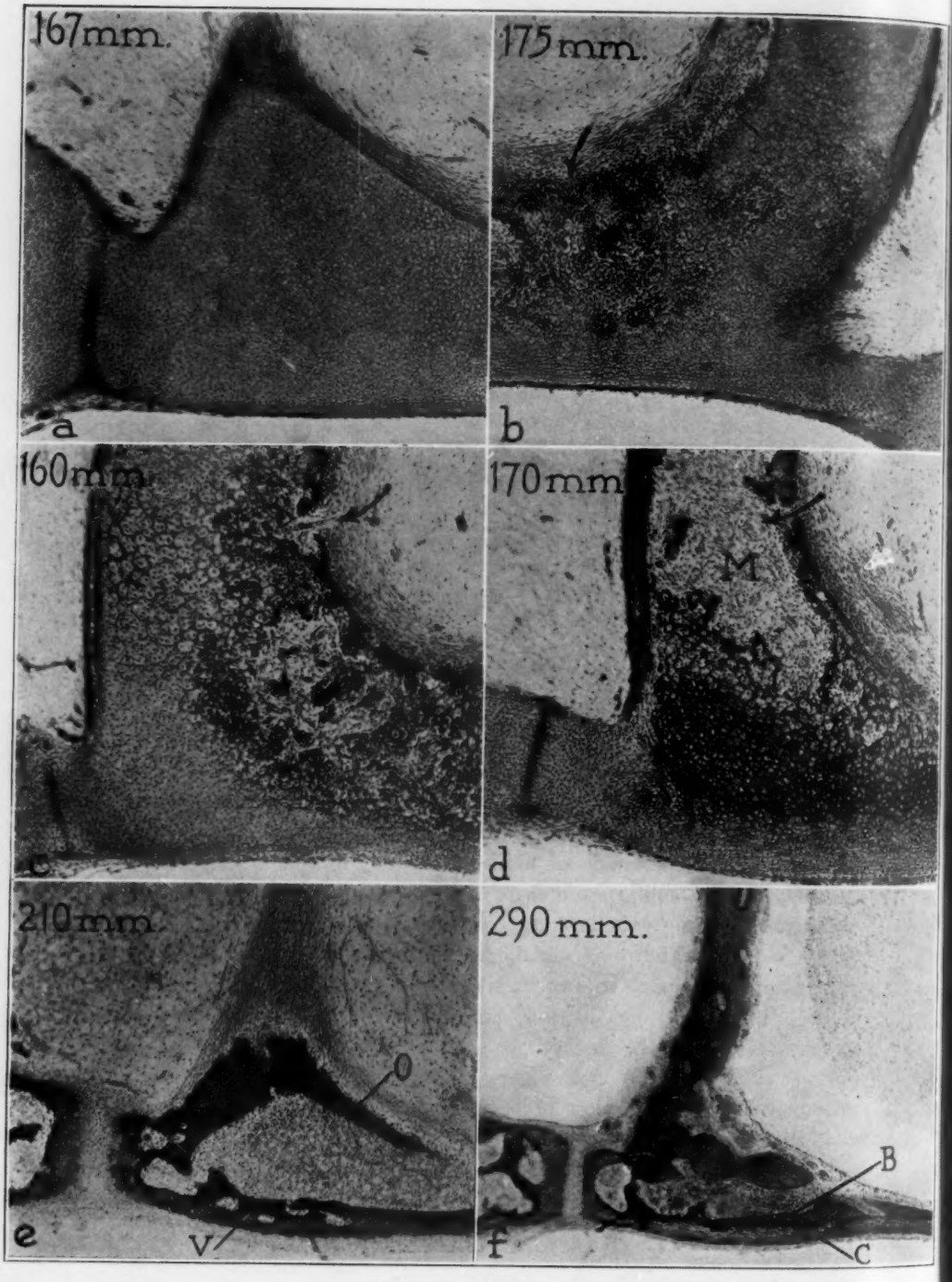
The following specimens are represented by drawings of reconstructions:

Length, Mm.	Wisconsin Series No.	Figure No.
160	41	9*a*, and *b*, 10*a* and *b* (See figs. 1*c*, 5*a* to *c*, from same series)
180	45B	11*a* to *c*, 12*a* to *d*
210	51	13*a* and *b* (See figs. 1*e*, 2*b*, 7*a*, 8*b*)
240	112	14*a* to *c*
275	4	15*a* to *c* (See fig. 7*c*)
Term	102	16*a* and *b*

As will be apparent from a preliminary survey of the illustrations, it is our plan to depict important levels in the fissular channels (e. g., fig. 3*a* to 3*c*, of the 167 mm. stage) and to record pictorially the morphologic features of the several portions of the stapes (e. g., fig. 4*a* and *b*, of the 175 mm. fetus).

OBSERVATIONS AND COMMENT

160 Mm. Fetus (19½ weeks; series 41).—At this crucial stage the stapes exhibits the initial histologic changes whereby a solid cartilaginous structure becomes converted into a hollowed ossicle, whose structure will be that of a foraminous shell of bone, with stapedial form. New bone formation is found principally on the obturator surface of the base and is of highly irregular, foraminous appearance (fig. 1*c*). The solitary center of ossification extends along the base to encroach on the vestibular rim of stable cartilage (fig. 5*b*); it involves principally the inferior (caudal) portion of the base along a line immediately proximal to the cartilaginous articular flange (figs. 9*a* and *b*; 10*a* and *b*). A narrow band of perichondrial bone surrounds the basal portion of the posterior crus. Ossification of the corresponding portion of the anterior crus forms an irregular pattern; the lower, or inferiorly directed, portion of the crus is first involved, with perichondrial ossification of a narrow zone anteriorly. As a consequence, a narrow strip of cartilage persists to separate two wings of perichondrial bone encroaching on the basal extremity of the anterior crus (fig. 9*a*). Hyaline cartilage of the primordial ossicle remains unaltered on the vestibular aspect of the base as a layer approximately one-eighth the total basal thickness; its free (vestibular) surface is covered by a dense perichondrium, which is continuous marginally with the stapedial



(See legend on opposite page)

ligament and with the fibrous covering of the vestibular wall. The opposite, or tympanic, aspect of the base is the scene of active osteogenic change; already a narrow, irregular plate of endochondral bone has been formed over the area of modified cartilage. Subjacent thereto, at the core of the base, the related tissues are predominantly a vascular marrow and a calcifying cartilage (fig. 1 *c*). Here true endochondral bone is sparse, a fact which indicates that the process is one of rapid destruction preparatory to rebuilding. Toward the marginal portion of the base, and at the broad areas of continuity of the base and the crura, the process is less pronounced. That portion of the now undisturbed hyaline cartilage which forms a thick stratum on the vestibular aspect of the base is destined to be retained throughout life. In this relatively inactive part of the basal cartilaginous layer, the sparse and pale-staining matrix, with small, densely packed chondrocytes, resembles closely the immature cartilage of antecedent stages.[2] The matrix is coarsely fibrillar peripherally, the fibers blending with those of the basal periosteum.

The newly formed bone, no more than a mere pellicle on the external aspect of the crus, is still uninterrupted by foramens (compare posterior crus of the 160 mm. stage, 9 *a*). On the external aspect it is a thicker layer. However, here the osseous "collar" is foraminous, being perforated by vessels which enter the opening from the vascular mesenchyma of the intercrural (obturator) space. The small vessels, supported by clumped mesenchymal cells, form the invasive osteogenic buds. The line of separation between the new bone and the old cartilage (now calcified) is very distinct. In the excavated portion of the base there occur occasional spicules of early intrachondrial bone (fig. 1 *c*).

The capital extremities of the crura and the entire head of the stapes are still wholly cartilaginous (figs. 9 *a*, 10 *a*). There is an

Fig. 1.—Photomicrographs of the base and crus of the stapes, showing progressive stages in the removal of cartilage and the formation of bone. × 40. (*a*) Base at posterior crus, left ear; 167 mm. fetus (Wisconsin series 105, slide 19, section 9). (*b*) Base and anterior crus, left ear; 175 mm. fetus (Wisconsin series 104, slide 17, section 5). (*c*) Posterior crus and base, left ear; 160 mm. fetus (Wisconsin series 41, slide 18, section 5). (*d*) Posterior crus and base, left ear; 170 mm. fetus (Wisconsin series 131, slide 21, section 10). (*e*) Posterior crus and base, left ear; 210 mm. fetus (Wisconsin series 51, slide 38, section 6). (*f*) Posterior crus and base, left ear; 290 mm. fetus (Wisconsin series 59, slide 36, section 1).

In *b* the arrow points to an area of peripheral erosion on the obturator aspect of the base. In *c* the arrow is directed toward an invasive bud and the newly made foramen, which transmits the osteogenic tissue with its blood vessels. In *d* the arrow passes through such a foramen from the circumstapedial mesenchymal tissue into the primitive marrow of the stapedial crus.

Abbreviations: *B* and *C* indicate bone and cartilage, respectively, of the bilaminar plate of the stapedial base; *M* represents the base of the stapes; *V*, vestibular layer of endochondral (endosteal) bone which forms one of the two constituent lamellas in the base of the stapes.

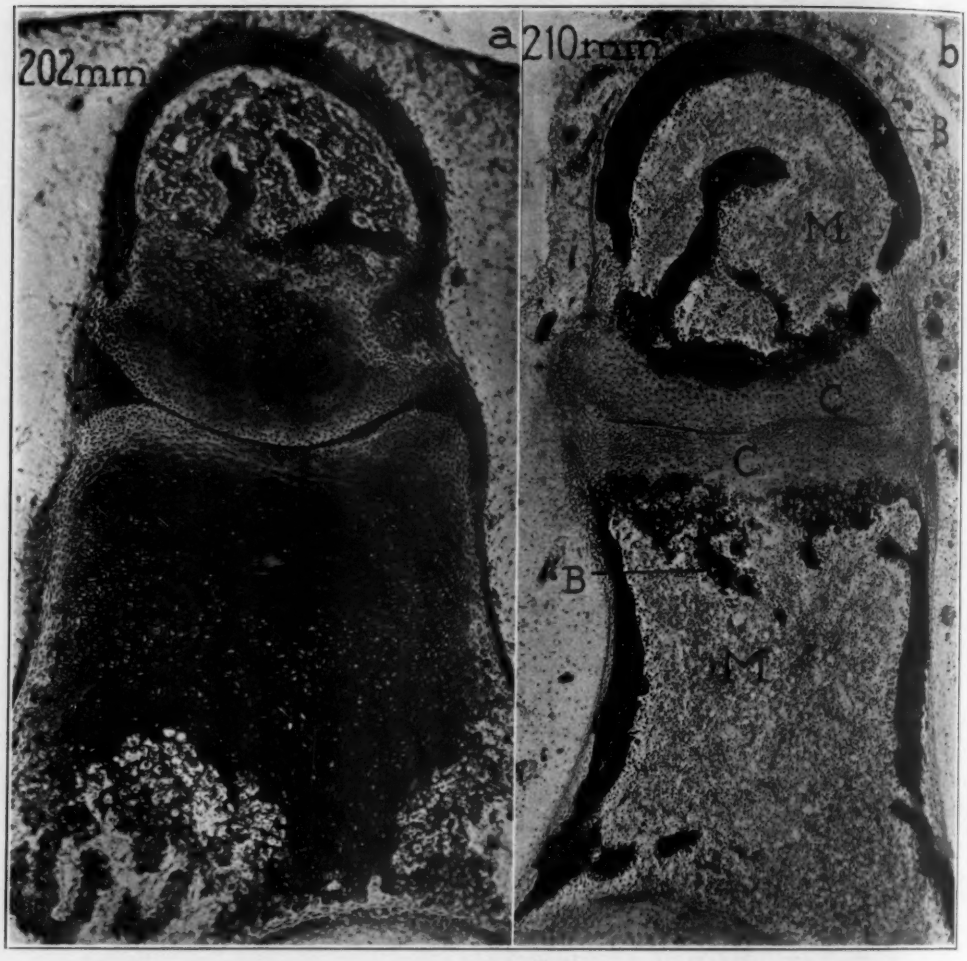


Fig. 2.—Photomicrographs of the neck and head of the stapes and of the lenticular process of the incus, showing erosion of the cartilage and its ultimate replacement (except where articular) by bone. × 40. (*a*) 202 mm. fetus (Wisconsin series 70, slide 27, section 6); (*b*) 210 mm. fetus (Wisconsin series 51, slide 38, section 6).

Abbreviations: *B* indicates bone (perichondrial in the incus, endochondral in the head of the stapes); *C*, cartilage (of the articular plates of the incus and stapes); *M*, marrow.

elevation at the point of attachment of the developing stapedial ligament.

At this stage, for the first time, there is evident the succession of steps by which the osteogenic process will ultimately involve the several divisions of the stapes, namely, basal, crural and, finally, capital portions. In the present instance the head has not yet been involved. On the midpart of the base erosion is deep; peripherally it is still

superficial. A thin vestibular lamina of hyaline cartilage remains unaffected. The excavated area contains a primitive fibrous marrow and some irregular deposits of calcified cartilage. Mainly, the process is still one of calcification and erosion of cartilage, and not of bone formation. The greater number of vascular buds enter from the intercrural (obturator) space, that is, from the internal aspect of base and crura; only an occasional bud enters from the external aspect. Such perichondrial bone as does exist is in the form of a relatively intact plate; sites of periosteal erosion are few and small in caliber.

The fissula ante fenestram is a narrow, fibrous seam in a rather bulky cartilaginous capsular mass (fig. 5 *a*). At the vestibular extremity, the peripheral cartilage is continuous with that forming the marginal cartilage of the vestibular window (fig. 5 *c*). The mass is being separated from the chondral shell of the cochlea through the activity of osteogenic buds. At the level of the auxiliary, or fenestral, opening of the fissula the relation of cartilage to bone is fundamentally similar (fig. 5 *b*). Peripherally the cartilage becomes calcified; farther away from the hyaline core the calcified tissue is being converted into intrachondrial bone. At the level of the tympanic opening the fissular cartilage is not yet segregated; it is continuous deeply (anteriorly) with the cochlear mass of cartilage. However, its vascular fibrous core communicates narrowly with that of the marrow at the cochlear end of the mass. The fibrous fissula, as it may conveniently be termed, has three orifices opening, respectively, on the tympanic cavity, on the vestibular (oval) window and on the vestibule at points not distantly separated from one another. The cartilage of the fissula (for which the fibrous tissue constitutes a core) extends without interruption from the tympanic cavity, through the otic capsule to the vestibule; at this stage its mass is being cut off from more anterior portions of the original capsule, as, at a slightly earlier stage, it was separated on those surfaces which now face marrow.

At this stage vacuolation of cartilage cells in the fissular region of the optic capsule is a prominent feature; the process is especially evident at the transverse level of the vestibular orifice of the fissula. At the level of the tympanic opening, however, there is no zone of altered cartilage to indicate where the cochlear shell will later be demarcated from the chondral shell of the fissula and from that of the vestibular window.

163 Mm. Fetus (20 weeks; series 33).—At the 163 mm. stage the basal and crural portions of the stapes have been excavated by vascular buds. The process of erosion extends a considerable distance through these portions of the ossicles, beginning on the inner (intercrural) wall (fig. 3 *d*).

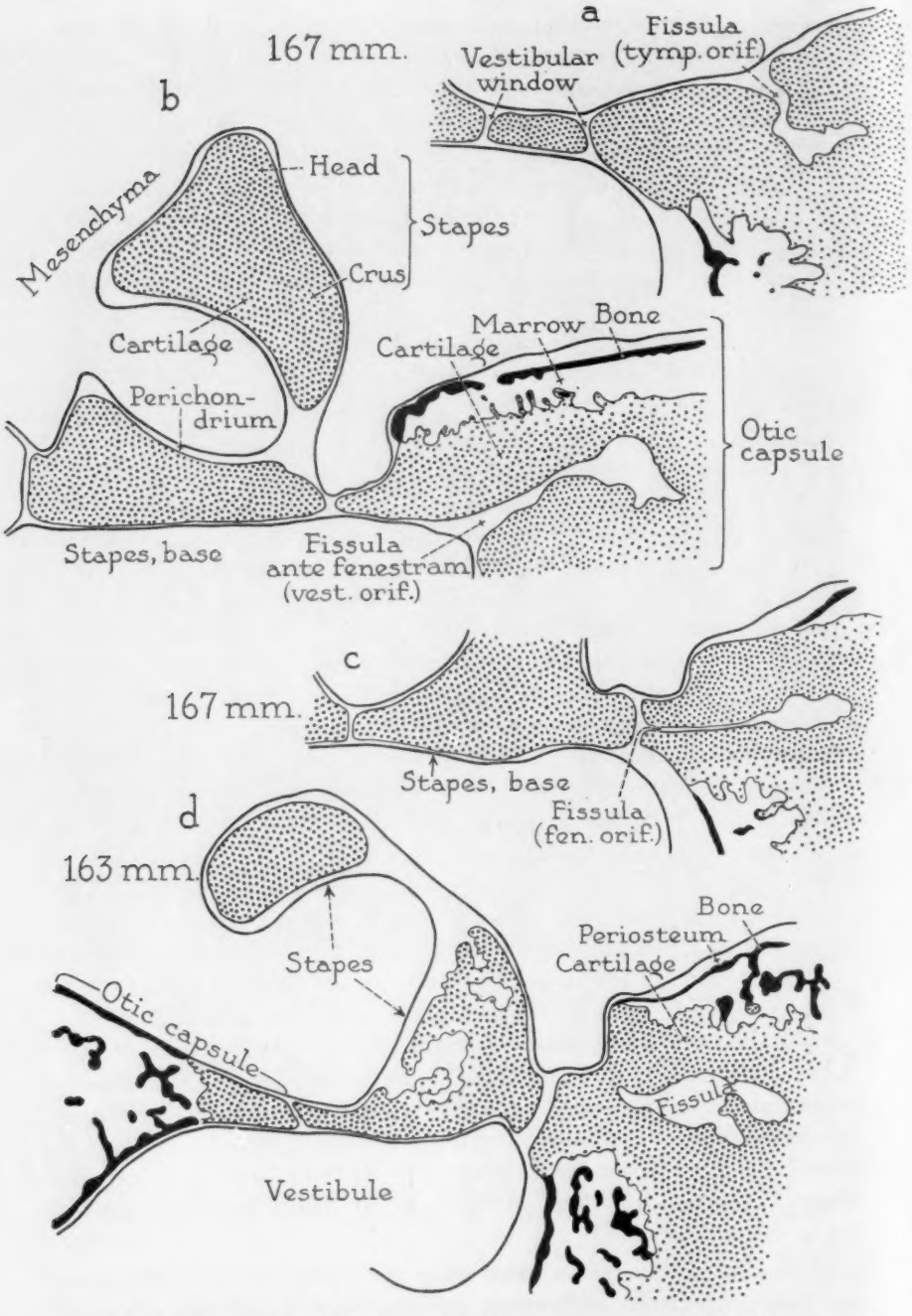


Fig. 3.—Drawings (semidiagrammatic) from Edinger tracings of the stapes and the adjacent fissular region of the otic capsule, showing developmental changes in the ossicle and in the fissular part of the capsule; × 6.6. Further developmental steps are recorded in the succeeding five plates of figures. In this, and in the five

(Legend continued on next page)

167 Mm. Fetus (20 weeks; series 105).—In this specimen the developmental processes are less advanced than those represented by the 160 mm. specimen (series 41). Calcification of the cartilage has not yet occurred; instead, merely enlargement and vacuolation of the chondrocytes are evidenced. These steps presage those of calcification. This preparatory process occurs on the tympanic aspect of the base, where the center of ossification later appears (fig. 1 *a*). The relatively precocious ossification of the capsule in the fissular area stands in sharp contrast to the lag in stapedial development.[3]

Reconstruction of subsequent stages demonstrates that full dimensions of the stapes have been attained in the 167 mm. fetus. All portions of the stapes are thick, and the intercrural space, as a result, is relatively small. Subsequent changes, therefore, are in the category of differentiation rather than of growth.

The fissular cartilage is continuous with that of the cochlea. Erosion, which is narrowing the fissular mass, is most active near the cochlear extremity (fig. 3 *b*). Between this mass and the perichondrial shell of the capsule the initial changes in osteogenesis are in evidence. There is a continuous fissular cleft from the tympanic to the vestibular surface, traversing the fenestral margin in its course (fig. 3 *c*). The fissula itself is a stripe of differentiated tissue in the cochlear division of the otic capsule. The cartilage in which the fissular fibrous tissue is lodged is continuous from the fenestral and vestibular walls to the

3. The malleus, on the contrary, is now composed partially of endochondral bone. Except for the articular surface, the articular end is bony, while the tympanic aspect of the base is still cartilaginous. The incus is osseous throughout the greater part of its length. In the reconstruction of the 161 mm. stage (Bast, T. H.: Contrib. Embryol. [no. 121] **21**:53-82, 1930), these differences are clearly evident.

following plates, regular stippling represents unaltered cartilage; less dense stippling stands for rarefied cartilage; the areas treated in black represent bone. Parts *a* to *c* are from a 167 mm. (20 weeks) fetus (Wisconsin series 105); (*a*) slide 23, section 8; (*b*) slide 21, section 9; (*c*) slide 19, section 9). Part *d* is from a 163 mm. (19 week) fetus (Wisconsin series 33; slide 17, section 8). Here, *a* is taken at the tympanic (cranial. or superior) orifice of the fissula ante fenestram; *b*, at the fenestral (intermediate) orifice; *c*, at the vestibular (caudal, or inferior) orifice and through the anterior crus of the stapes, and *d*, through the body, or midportion, of the fissula.

Abbreviations in this and in succeeding plates are interpreted as follows: *Ant.* or *Ant. crus,* anterior crus; *Cartil.,* cartilage; *fen. orif.,* fenestral orifice (of fissula ante fenestram); *Post.* or *Post. crus,* posterior crus; *Tymp. cav.,* or *Tymp. cavity,* tympanic cavity (middle ear); *tymp. orif.,* tympanic orifice (of fissula); *Vest.,* vestibule; *vest. orif.,* vestibular orifice (of fissula); *V. w.,* vestibular (oval) window.

The stapes of the 167 mm. fetus is still wholly cartilaginous; in the capsule, on the contrary, bone is replacing cartilage(seen on the vestibular surface in *a*, on the tympanic aspect in *c* and on both surfaces in *b*). In the course of this process the cartilage of the fissula becomes separated.

In the 163 mm. fetus ossification of the capsule has progressed further; the base and crus of the stapes have been excavated, but bone has not yet appeared.

cochlear wall. Bone is being formed around the fissula, segregating the mass on the lateral and medial sides. The vestibular extremity is of typically elongate form (fig. 3 *b*). The tympanic extremity is small

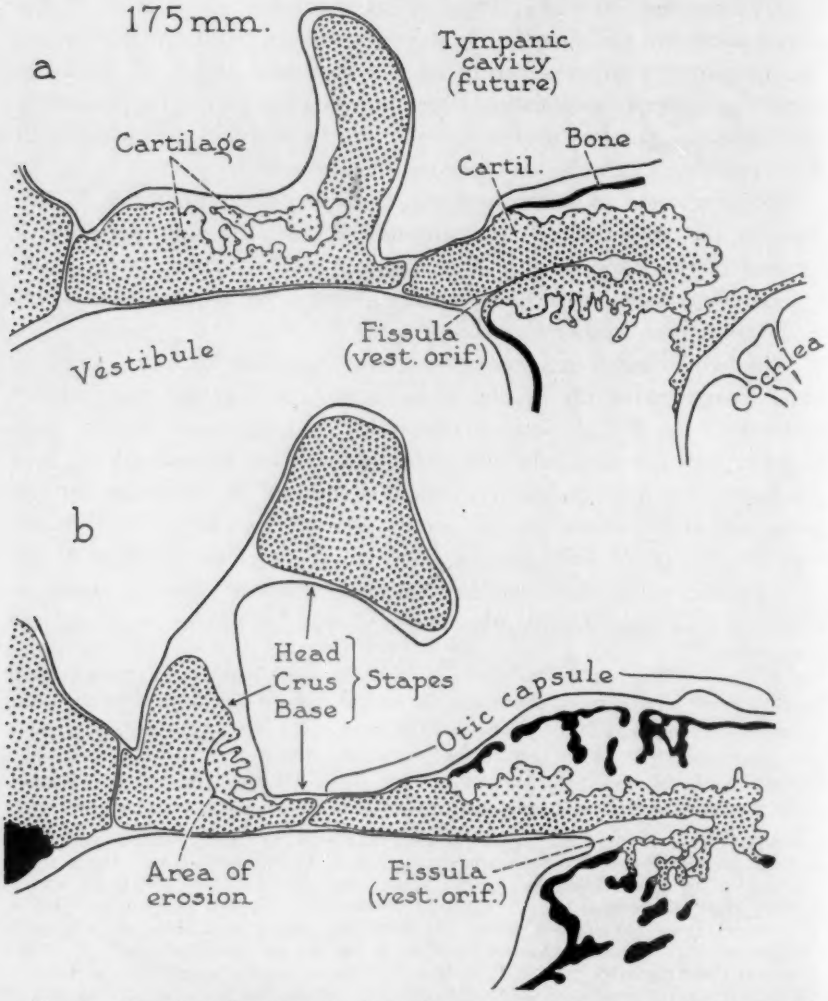


Fig. 4.—Drawings (continued) of developmental stages from a 175 mm. (20 week) fetus (Wisconsin series 104: (*a*) slide 17, section 5; (*b*) slide 16, section 2); × 6.6.

The stapes is now excavated on the obturator surface of the base (*a* and *b*), at the basal end of the anterior crus (*a*) and in the corresponding portion of the posterior crus (*b*). However, bone has not yet formed over the eroded area. In the antefenestral portion of the capsule, periosteal bone, which appears in the form of thin laminas, does not extend to the vestibular window. In the latter portion of the capsule the fenestral shell of cartilage is continuous with that which encloses the fissular tract of connective tissue. The fissular shell of cartilage is becoming detached, at its opposite (or anterior) extremity, from the cartilaginous wall of the cochlea (*a*). In the region between the vestibule and the cochlea, spicules of intrachondrial bone now are present, having been formed as a result of rapid ossification of persistent spicules of cartilage (*b*).

(fig. 3 *a*); it is an almost circular orifice, a form typical of the adult fissula. The fenestral opening is narrow (fig. 3 *c*).

With respect to form and structure, the fissula in this specimen is important both as a stage and as a type. A crucial phase in development is represented by the early erosion of the medial and lateral aspects of the main mass of cartilage in which the fissula (fibrous tissue) is lodged. In this specimen, the fissula constitutes a continuous stripe between the fenestral and the cochlear part of the original capsule. The fissula does not possess separate orifices. Correspondingly, an "opening" occurs in an oblique line downward and medialward, as an uninterrupted cleft from the tympanic wall of the otic capsule, across the fenestral, to the vestibular wall.

Retention of the narrow stripe of fibrous tissue, characteristic of the embryonic type of fissula, is an unexpected feature at this stage, in view of the fact that perichondrial bone will be soon added to the tympanic wall and endochondral bone will be abundantly laid down adjacent to the fissular tract.

170 Mm. Fetus (20 weeks; series 131).—Stapedial development is further advanced in the 170 mm. fetus than it is at the 160 mm. stage (series 41). The cartilage of the crura has been almost completely removed, leaving hollow cylinders of periosteal bone to invest fragments of hyaline cartilage and calcified cartilaginous remnants (fig. 1 *d*). The bone of the internal surface of the osseous crura is foraminous; that of the external aspect remains unbroken. The process of excavation is more advanced in the posterior than it is in the anterior crus (fig. 5 *e*). Whereas perichondrial bone surrounds the crura and covers the tympanic aspect of the base, it has not yet extended to the stapedial head.

In the otic capsule, perichondrial bone approaches the tympanic and vestibular orifices of the fissula (fig. 5 *d* and *f*). Destruction of cartilage is followed chiefly by the formation either of primitive marrow spaces or of intrachondrial bone; endochondral bone is inconspicuously present in the form of small spicules. The fissular cartilage is broad; its contained connective tissue is vascular. The vestibular orifice is wide (fig. 5 *f*) and is continuous with a well defined fenestral opening (fig. 5 *e*). The tympanic extremity is narrow; however, it broadens quickly as it extends into the adjacent mass of cartilage (fig. 5 *d*). This type of fissula ante fenestram is very unlike that in which fibrous tissue appears as a mere streak within the fissular cartilage. The cartilage of the fissula is still broadly continuous with that of the cochlea.

175 Mm. Fetus (20 weeks; series 104).—Although the stapes is still entirely cartilaginous, the process of osteogenic excavation is appreciably advanced (fig. 4 *a* and *b*). Osteogenesis affects the

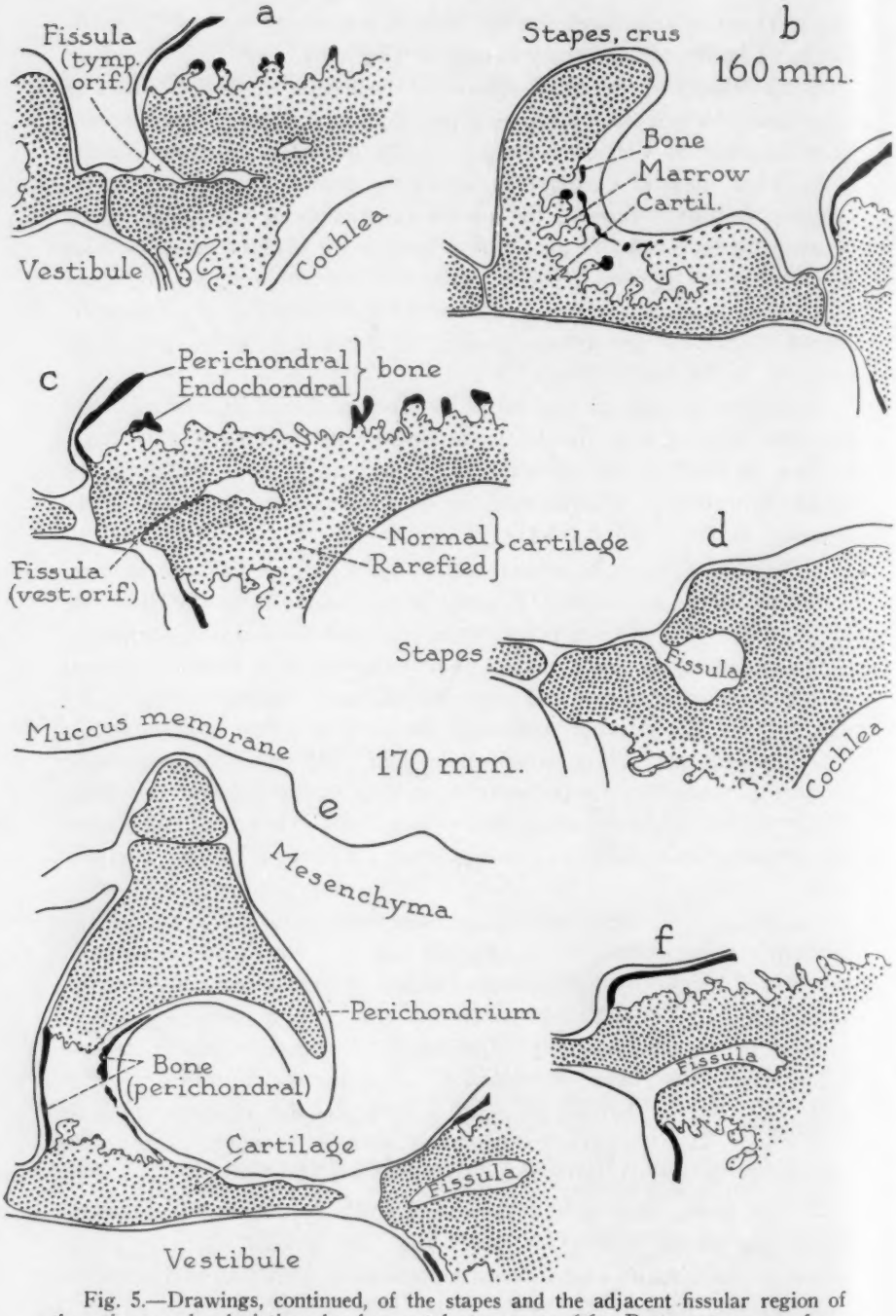


Fig. 5.—Drawings, continued, of the stapes and the adjacent fissular region of the otic capsule, depicting developmental stages; × 6.6. Parts *a* to *c* are from a 160 mm. (19½ week) fetus (Wisconsin series 41: (*a*) slide 19, section 4; (*b*)

(Legend continued on next page)

tympanic aspects of the base and the internal surface of the basal portion of each crus (fig. 1 *b*). The head of the stapes is unchanged. The surrounding mesenchyme, now highly vascular, is the source of the abundant osteogenic buds which invade the basal and crural portions of the stapes.

The fissular cartilage has become almost separated from the cochlear cartilage by the process of gradual erosion. Perichondrial bone has spread to the anterior aspect of the tympanic orifice, but has not yet encroached as deeply on the cartilage of the vestibular window as it has on the chondral wall of the vestibular extremity. In the latter situation bone has almost reached the vestibular orifice of the fissula. The fissular shell of cartilage appears as an elongate stripe extending from the cochlea to the vestibular window (fig. 4 *a*). Its connective tissue approaches, but does not reach, the fenestral margin, there being, consequently, no auxiliary (fenestral) orifice.

179 Mm. Fetus (20 weeks; series 135 B).—Osteogenesis has advanced beyond the stage seen in the 170 mm. fetus (series 131); the stapes is very similar to that of the 205 mm. specimen (series 7).

The fissula, like that of the 167 mm. fetus (series 105), is a narrow seam, whose usually separate orifices are continuous. The fibrous tissue within the obliquely coursing cleft is thereby applied to the perichondrium throughout its extent (from the tympanic wall, across the window, to the vestibule).

180 Mm. Fetus (21 weeks; series 137 and 45 B).— The stapes is similar in its developmental stage to that of the 205 mm. specimen (series 7). Fenestrated periosteal bone, present on the crura, encloses marrow tissue. However, in fetus 137 the ossifying process has not yet involved the entire wall of the intercrural space; it fails to reach the capital portion. In fetus 45 B there is rapid spread of periosteal and endochondral bone, involving the base, the crura and the basal portion of the head (fig. 12 *a* to *d*). The accompanying extensive excavation of the cartilage converts these portions of the ossicle

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slide 18, section 8; (*c*) slide 17, section 9). *d* to *f*, from a 170 mm. (20 week) fetus (Wisconsin series 131: (*d*) slide 25, section 5; (*e*) slide 21, section 10; (*f*) slide 20, section 8). Here, *a* is taken at the level of the tympanic orifice of the fissula ante fenestram; *b*, through the middle of the fissular tract and the posterior crus of the stapes; *c*, through the vestibular orifice of the fissula, and *d* to *f*, from sections of the 170 mm. fetus which pass through similar levels of the fissula and ossicle (in succession, the tympanic extremity, the body and the vestibular extremity of the fissula).

In the 160 mm. specimen destruction of cartilage is under way; bone is formed on the obturator aspect of the base and crus of the stapes and on the tympanic and vestibular walls of the otic capsule. Concurrently, the cartilage of the fissula has become partially separated; while almost detached at its cochlear end, the fissular cartilage is still broadly continuous with similar tissue at the vestibular window.

In the 170 mm. fetus newly formed bone is present on both aspects of the crus as a complete shell externally, as a foraminous wall internally (i. e., toward the obturator foramen).

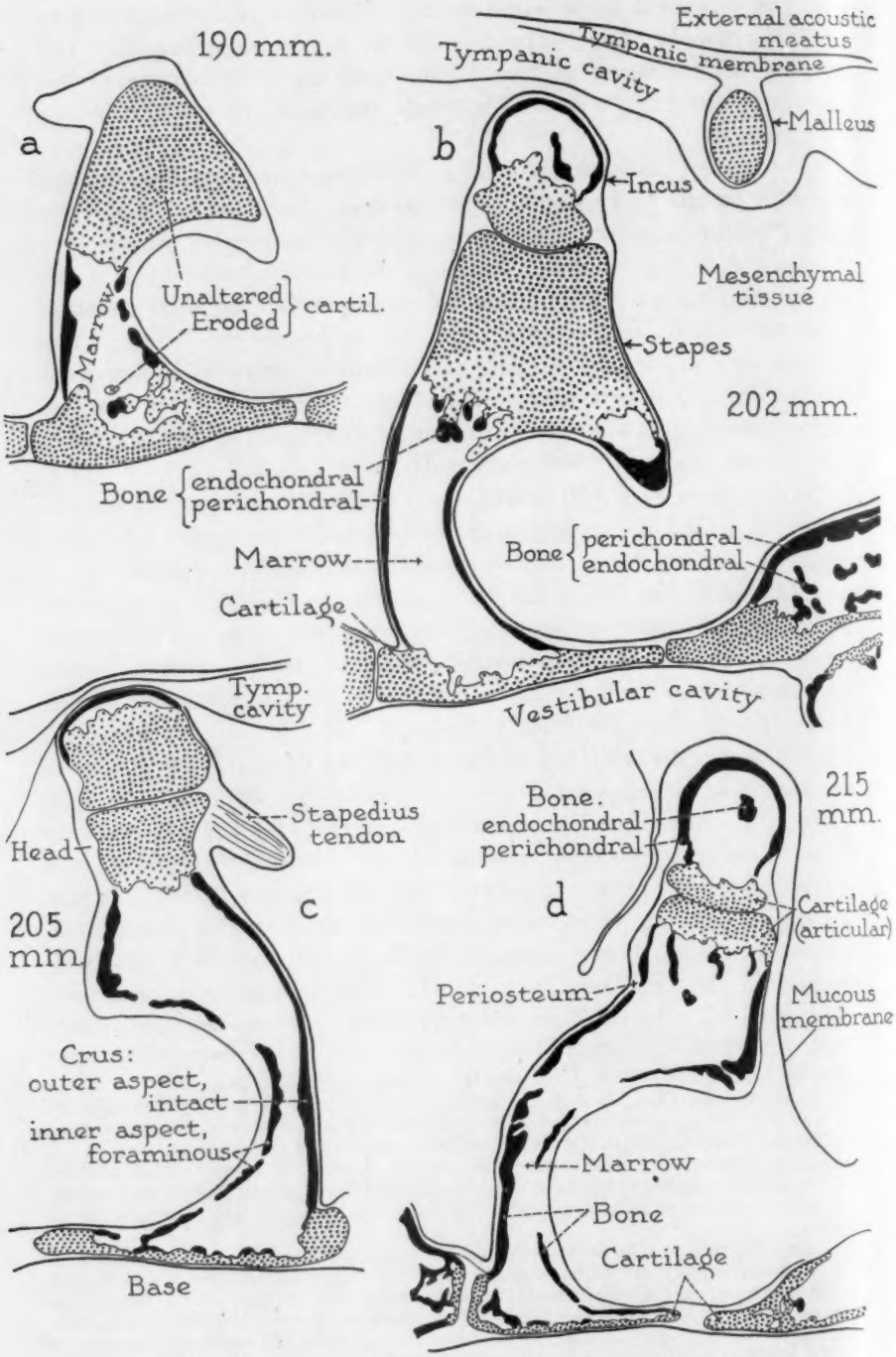

Fig. 6.—Drawings of crucial developmental stages, continued: × 6.6. (*a*) 190 mm. (21 week) fetus (Wisconsin series 29A, slide 18, section 1); (*b*) 202 mm.

into hollowed members, whose contained cavities are continuous. Irregular masses of calcified cartilage occur in the crurocapital and basal areas. The periosteal shells of bone, which form the peripheral portions of the crura, are becoming foraminous. These features would place this stage, developmentally, immediately antecedent to the 205 mm. specimen (series 7).

The vestibular window is now set off sharply from the remainder of the differentiating otic capsule; it has assumed the form of a cartilaginous ring lodged in a framework of periosteal and endochondral bone. The periosteal bone meets, and slightly overlaps, the cartilage of the fenestral rim in exactly the same way that comparable bone of the stapedial head overlaps the cartilage which is there being gradually replaced. Endochondral bone is present in the form of discontinuous collections surrounded by primitive marrow.

The fissular tract of connective tissue is embedded in a considerable cartilaginous mass. The cartilage appears especially massive because of its association with a surrounding collection of delicate endochondral fragments. On the tympanic wall the fissula ends in two small orifices (fig. 11 *a* to *c*). The tympanic extremity meets the body of the fissula at a right angle, as it does regularly in postnatal specimens. This observation indicates that the form of the fissula is fixed during the stage at which the cartilaginous otic capsule is being converted into an osseous "box." A wide fibrocartilaginous cupola extends cranially for a considerable distance above the tympanic orifice (fig. 12 *a*).

In fetus 137 the fissula approaches, but does not actually reach, the vestibular window; it also fails to open on the tympanic surface of the otic capsule. This is an important fact in the interpretation of the adult condition in some specimens, since in several such specimens previously studied the tympanic opening was wanting. Formerly, we had ascribed this "aberrancy" to a late, obliterative overgrowth of periosteal bone. Now it is clear that it may be due to embryonic

(23 week) fetus (Wisconsin series 70, slide 27, section 6); (*c*) 205 mm. (23 week) fetus (Wisconsin series 129, slide 20, section 3); (*d*) 215 mm. (24 week) fetus (Wisconsin series 62, slide 28, section 4). Parts *a*, *b* and *d* represent sections from series of the left ear; *c* is from the right ear; all represent the transverse level of the posterior crus of the stapes.

Four further steps in the progress of stapedial ossification are illustrated. In the 190 mm. specimen, the process of ossification has spread to the base of the stapes, but has not yet affected either the neck or the head of the ossicle (*a*). At the 202 mm. stage excavation of the neck is in progress. (*b*) This developmental phase has been completed in the 205 mm. specimen; additionally, endochondral bone is being deposited on the internal surface of the excavated basal plate of cartilage. (*c*) In the 215 mm. fetus the articular plate of cartilage on the head of the stapes, now fully excavated, is being converted by a similar process into a bilaminar articulation. (*d*) Concurrently, a like series of changes is taking place in the lenticular process of the incus. Destruction of periosteal bone on the obturator surface of the stapes keeps pace with the formation of endochondral bone within the capital and basal portions of the ossicle.

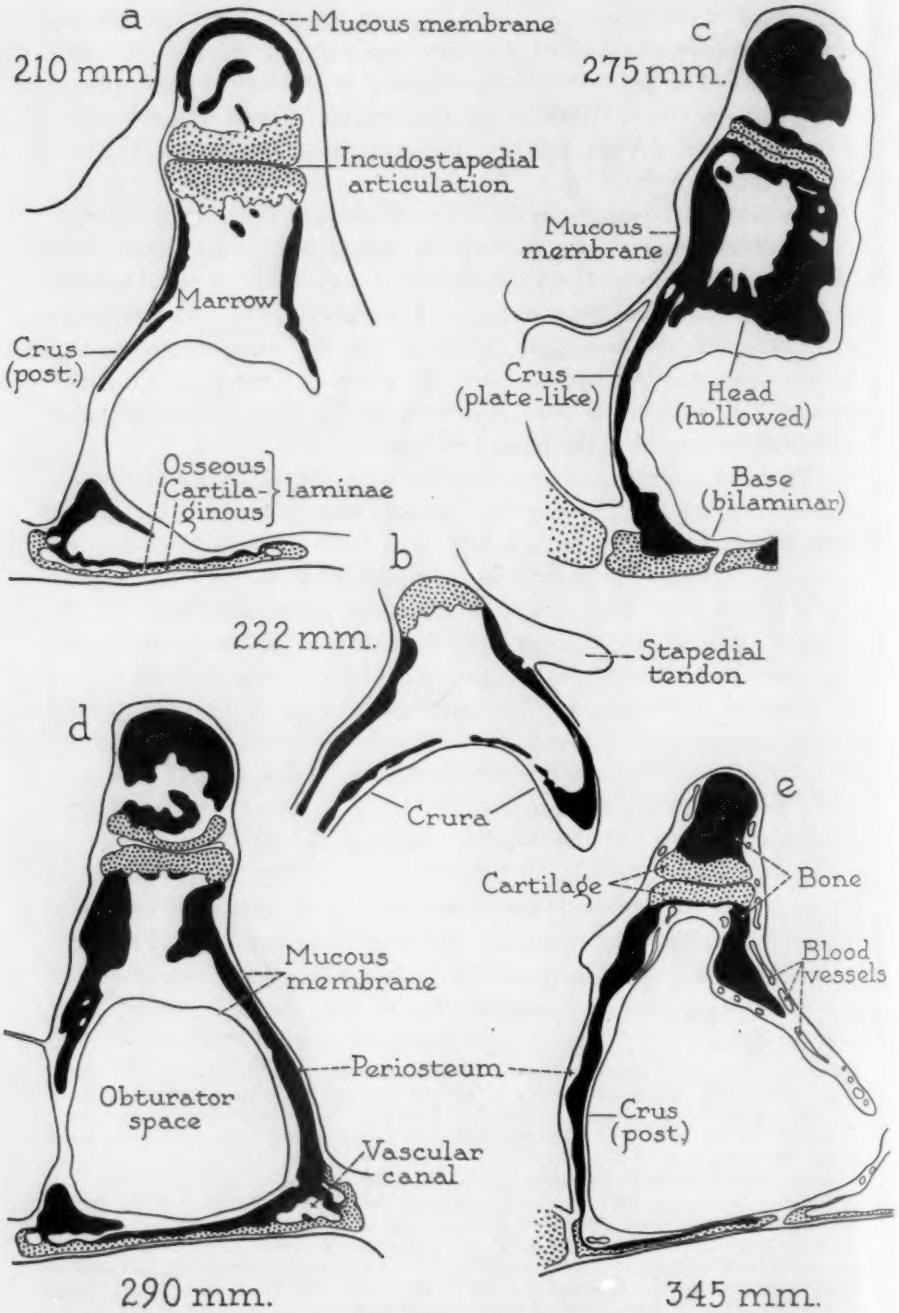

Fig. 7.—Drawings of developmental stages, continued; × 6.6: (*a*) 210 mm. (23 week) fetus (Wisconsin series 51, slide 38, section 5); (*b*) 222 mm. (25 week) fetus (Wisconsin series 46, slide 19, section 10); (*c*) 275 mm. (30 week) fetus

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failure to establish, or to retain, such an opening during the period when the surrounding tissue is still cartilage.

190 Mm. Fetus (22 weeks; series 29 A).—The process of excavation of cartilage in the stapes has not progressed so far as in the 205 mm. fetus (series 7, to be described later) and is well behind that in the 180 mm. fetus (series 45 B, described in preceding section). The head and neck of the stapes are still composed of unaltered cartilage (fig. 6 *a*). The crura show the effects of extensive excavations; in each crus periosteal bone is intact on the outer aspect, but is foraminous on the inner (obturator) surface. The excavated crura contain marrow. Small remnants of calcified cartilage and intrachondral bone are found. Excavation of the base has progressed beyond that represented by the 160 mm. stage (series 41), but not so far as in the 180 mm. stage (series 45 B).

The fissula possesses narrow orifices and a relatively wide midportion, or body. The fissular cartilage is being invaded peripherally by osteogenic buds. The cartilage does not quite reach the cochlear wall. Since the entire capsule was originally formed in cartilage (all cartilage persisting at later stages being remnants), it may be said with certainty that the reduction in length of the fissular cartilage is due to replacement of cartilage by bone, as is evidenced, at this 190 mm. stage, in the reduction of width of fissular mass.

193 Mm. Fetus (22 weeks; series 85 B).—In general structure, this stage is more advanced than the 190 mm. fetus (series 29 A) and the 180 mm. specimen (series 137 or series 45 B); with respect to certain features it is even beyond the 205 mm. fetus (series 7) in development. The stapedial crura are completely channeled. The old foraminous wall of the base remains in part. Internal to this disappearing wall, on the tympanic (lateral) cartilaginous lamella of the base, bone is spreading rapidly to form an osseous plate. The cartilage of the head of the stapes is also deeply excavated; like the crura, it has attained the form characteristic of the adult ossicle. The base

(Wisconsin series 4, slide 25, section 4); (*d*) 290 mm. (32 week) fetus (Wisconsin series 59, slide 36, section 5); (*e*) 345 mm. (38 week) fetus (Wisconsin series 61, slide 42, section 1).

In the 275 mm. specimen investment of the cartilaginous lamina of the stapedial base by endochondral bone has been completed (*a*); fusion of the peripheral remnant of perichondrial bone on the obturator aspect of the base (*a*) with the newly formed endochondral bone has resulted in the formation of osseous canals for the transmission of blood vessels (*d*). The mucous membrane and associated submucosal tissue, which in the 210 mm. specimen have already replaced the primitive marrow of the crura (*a*), later spread medialward to invest the endochondral and other bone of the base (290 mm., *d*); they ultimately invade the excavated neck and head of the stapes (345 mm., *e*). Thus, with regard to form, the stapes is essentially an adult ossicle in the 290 mm. fetus (*d*); with respect to mucosal relations, the ossicle attains adulthood at the 345 mm. stage (*e*) (compare with fig. 8 *e*, from the newborn).

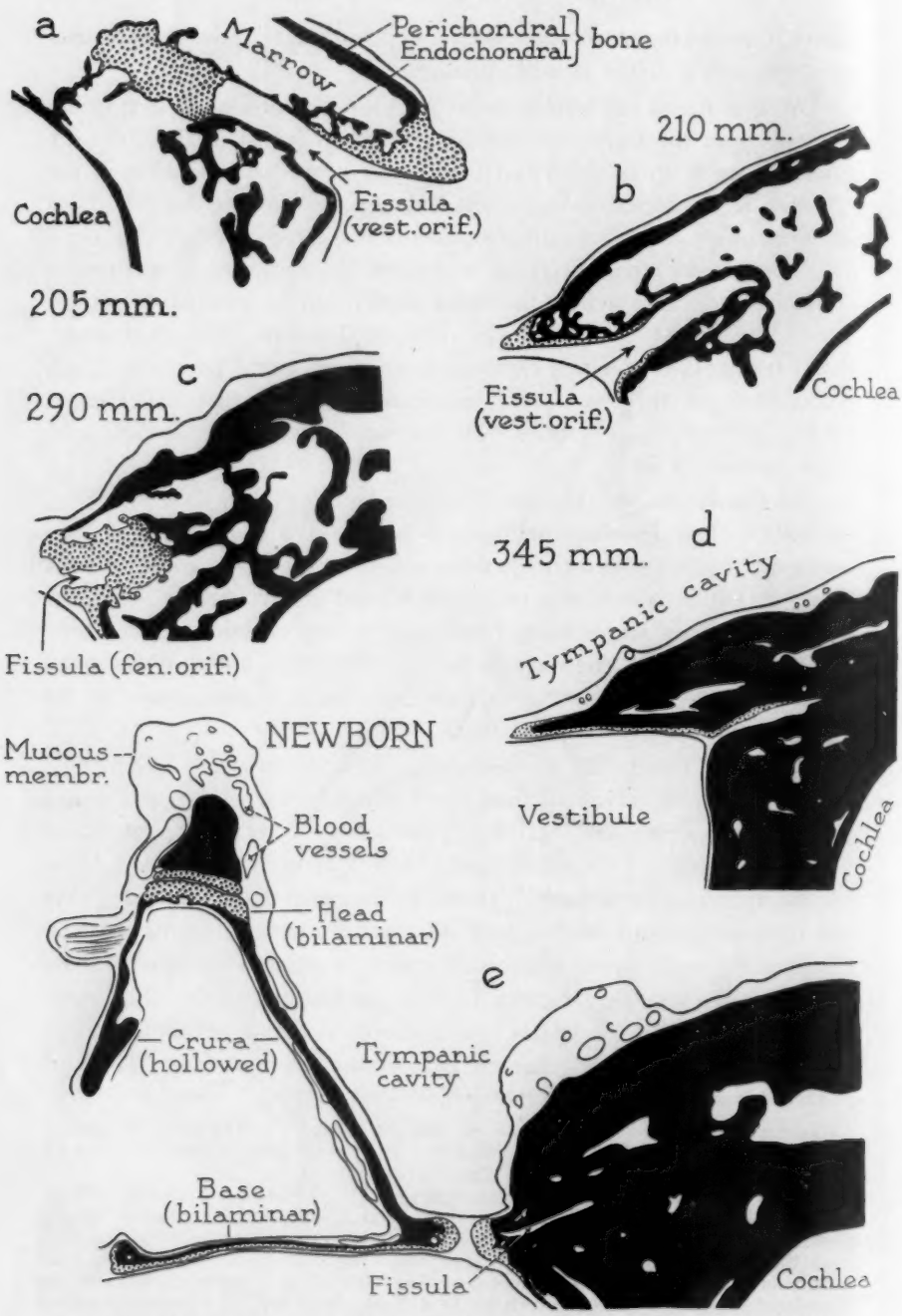

Fig. 8.—Drawings of developmental stages concluded. × 6.6: (*a*) 205 mm. (23 week) fetus (Wisconsin series 129, slide 20, section 3); (*b*) 210 mm. (23 week) fetus (Wisconsin series 51, slide 38, section 5); (*c*) 290 mm. (32 week) fetus (Wisconsin series 59, slide 36, section 5); (*d*) 345 mm. (38 week) fetus (Wisconsin

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retains but part of its fenestrated wall. In subsequent stages the foraminous walls of the crura and base will be wholly removed, through widening and coalescence of the foramens, to render the resultant space continuous around the entire obturator aspect of the ossicle. Concurrently, marrow will be replaced by loose fibrous tissue.

The cartilaginous fissula is likewise in a more advanced stage of development. Bone of the capsule has spread into the fenestral and fissular areas, leaving cartilage as a relatively inconsiderable remnant. The fenestral cartilage is thinned through circumferential encroachment of bone. The surface area of the cartilage exposed to the vestibule and to the tympanic cavity has become greatly reduced in comparison with its extent in the earlier stages, having virtually assumed the form exhibited by that cartilage in the fetus at term and in the infant.

The fissular cartilage, likewise, is greatly diminished in bulk and is receding from the originally continuous cochlear cartilage. At the vestibular extremity of the fissula, periosteal bone approaches the orifice, and cartilage, continuous with that of the fissula, extends over a rather small, adjacent area of the vestibular wall. The exterior of the cartilaginous mass is invested with intrachondrial bone, a circumstance which indicates rapid deposition of bone on partially destroyed cartilage. The two tissues remain thus associated in the adult ear, with, however, relative reduction in the bulk of the cartilage.

Near the fissular cartilage are situated separate spicules, consisting of a combination of intrachondrial and endochondral bone. As such spicules increase in number and in dimensions, they will close the space which at this stage exists between the periosteal shells of tympanic cavity, cochlea and vestibule. Even after coalescence of the now separate elements the constituent tissue will contain the cartilage islands, which here are encountered in their earliest stage of formation.

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series 61, slide 42, section 1); (*e*) newborn infant (Wisconsin series 315, slide 20, section 8). Parts *a*, *b* and *d* are from sections through the vestibular orifice of the fissula; (*c*) and (*e*), from sections at the fenestral orifice.

The cartilage which surrounds the fissula ante fenestram in the 202 mm. specimen (fig. 6 *b*) as a thick chondral layer, bordered by spicules of intrachondrial bone, undergoes rapid reduction in bulk to become, at the vestibular extremity, an osseous shell lined by a thin stratum of persistent cartilage or by a perichondrium (205 and 210 mm., *a* and *b*). Cartilage still persists at the cochlear extremity of the fissula as a considerable mass (205 mm., *a*); similarly, it still remains at the fenestral extremity, where the fissular cartilage is still continuous with similar tissue which lines the vestibular window (290 mm., *c*). While the cartilage is being gradually reduced in bulk, the marrow space, which everywhere surrounds the fissula, becomes occupied by endochondral bone. At first, spicules of intrachondrial bone are sparsely distributed in the area between plates of perichondrial bone (205 and 210 mm., *a* and *b*); endochondral bone next forms around these spicules (290 mm., *c*), finally converting the capsule into a petrous structure (345 mm., *d*; newborn, *e*). Thus, in the newborn (*e*), the capsule has acquired an adult appearance, as has the stapes.

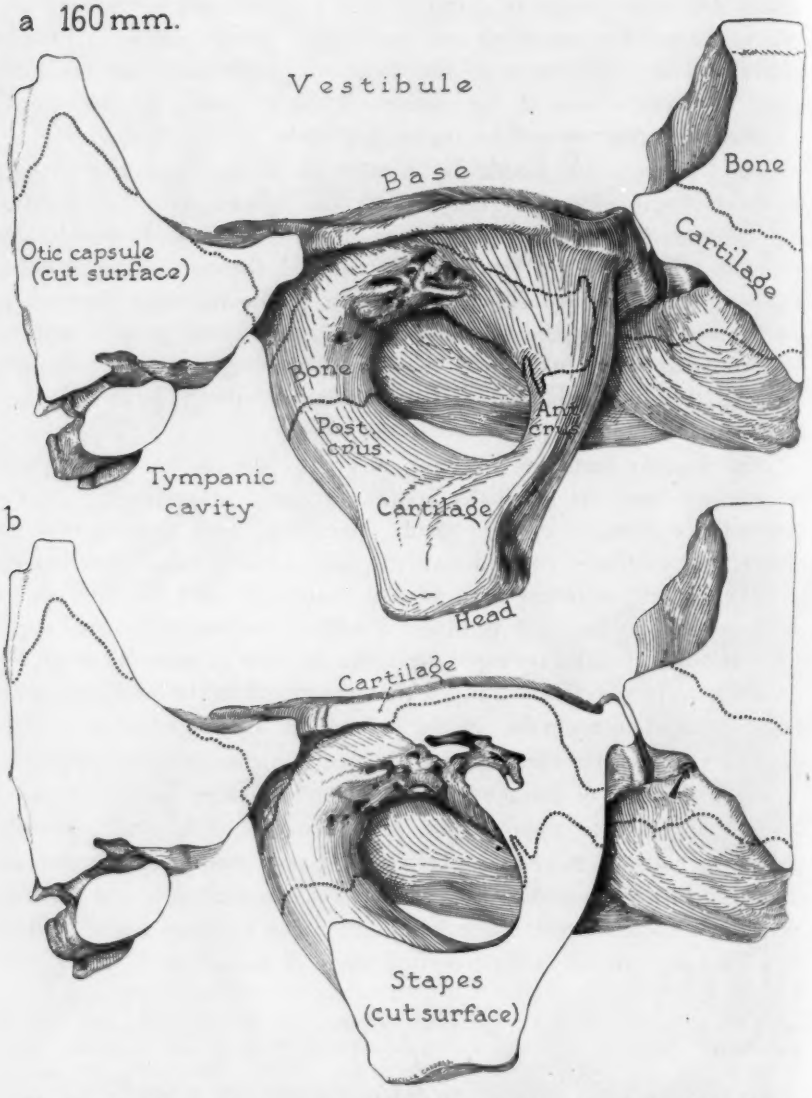

Fig. 9.—Drawings of a reconstruction of the stapes and adjacent portions of the otic capsule in a 160 mm. (19½ week) fetus (Wisconsin series 41); superior (cranial) views; × 7: (*a*) of the stapes entire; (*b*) with an upper segment of the stapes removed (in the plane of the constituent transverse section), showing erosion of the stapedial base and of the basal extremities of the crura. The dotted lines on the stapes indicates the approximate limits of the ossifying area; to either side of the area bounded by these lines, the cartilage of the base (on the vestibular surface) and of the head, neck and capital extremities of the crura (toward the tympanic aspect) is as yet unaltered. Similarly, osseous and cartilaginous portions of the capsule are indicated. In *b* the arrow enters the tympanic orifice of the fissula; in figure 10 *b* the arrow enters the junction of the vestibular extremity and the body of the fissula.

202 Mm. Fetus (23 weeks; series 14 and 70).—In fetus 70 stapedial morphogenesis is not so far advanced as in the 205 mm. fetus (series 7). However, fissular development is further advanced in the former specimen. The stapedial base is excavated deeply. The portions of the osseous crura and base facing the obturator space are extensively foraminous. The capital cartilage is not so deeply excavated as are the crura and base.

The stapedial head is still entirely cartilaginous (fig. 2*a*). Osteogenic vascular buds have encroached on the future neck of the stapes, with resultant patchy change to calcified cartilage. The crura are completely excavated internally; these tubes are filled with marrow, which now extends through the space from the neck to the base (fig. 6*b*). At the latter site, the basocrural portions are made up of unaltered cartilage, covered by a thin and irregular plate of calcifying cartilage. The greater part of the base is excavated, leaving an obturator wall of foraminous periosteal bone. Small portions of endochondral bone are formed in the capital extremities of the crura (fig. 2*a*).

The fissular cartilage remains as a shell for the contained connective tissue and forms a terminal bulbous mass at its cochlear end. It is lined with bone on the medial aspect of the vestibular orifice.

Bone covers the cartilaginous rim of the vestibular window. This shell is mergent on its attached, or deep, aspect with spicules of intrachondrial bone, some of which still constitute a bridge between fissular cartilage and the now osseous cochlear wall.

In series 14 osteogenesis of the stapes is more advanced than in series 70 (figs. 2*a*, 6*b*). Almost no endochondral bone remains within the crura or head; the stage is preparatory to that in which the osseous obturator wall and contained marrow become, respectively, removed and replaced. The perichondrial bone of the head approaches the plaque of cartilage which, of the entire chondral mass, will alone be retained to serve as an articular plate. The base is deeply excavated from within, the cartilage now being thickest peripherally, where it forms the flangelike projection toward the fenestral rim.

Thus, there remains a basal plate of cartilage, not much thicker than it will be when definitive endochondral bone is laid down on its obturator surface. This means that crural development is most rapid and capital development slowest and that the base stands developmentally in an intermediate position.

205 Mm. Fetus (23 weeks; series 7).—On the capital extremity of the stapes unaltered cartilage persists as a relatively limited area, adjacent to which is a narrowing zone of calcifying cartilage (fig. 6*c*). Ossification is complete in the crura, these once separate osseous cylinders now being connected by bone across the lateral (capital)

aspect of the obturator foramen. The obturator surface of each crus is strikingly foraminous. Excavation of the base has progressed to the point at which the obturator wall is extensively foraminous, and the vestibular portion is a cartilaginous plate on the internal surface of which numerous small zones of calcified cartilage are being replaced by endochondral bone (fig. 6 *c*).

This stage is a critical one in the whole process of reconstruction of the stapedial base. Endochondral bone is extending across the

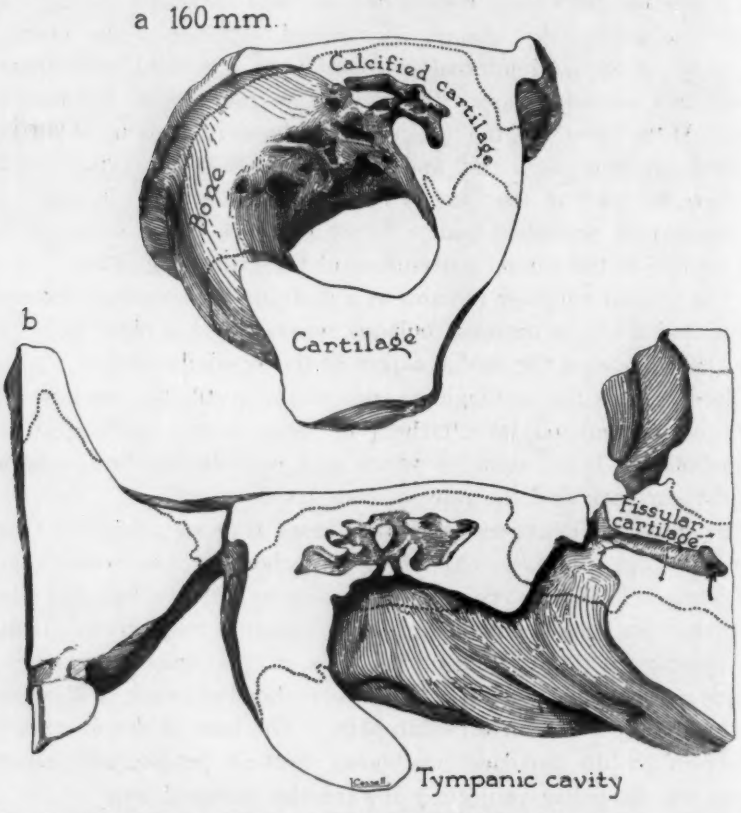

Fig. 10.—Drawings, continued; same specimen (160 mm.) as in figure 9 *a* and *b*. × 7; (*a*) at the same level as figure 9 *b*, viewed from a more lateral position, in order to reveal the number and size of the foramens present in the periosteal plate on the obturator surface of the base and on the basal extremities of the crura; (*b*) a more inferior segment of the stapes and of the otic capsule (viewed as are 9 *a* and *b*), showing cavities produced in the calcifying cartilage preceding the stage of complete excavation of the base. Here, and in figure 9 *a* and *b*, the osseous shell externally and the calcifying cartilage internally merge imperceptibly in a transitional zone. In *b* of figure 10 the hummocks exposed in the basal portion of the stapes are composed chiefly of calcified cartilage; their summits are capped by either endochondral or intrachondrial bone.

eroded internal surface of the cartilaginous lamina. This new bone is connected with the original, now foraminous, primary (perichondrial) layer by a few elongate spicules. Between the old cartilage and the

new bone, vessels remain in widened canals. Some of these, judging from the later appearance of the base, are of transitory nature; others will remain as nutrient vessels. The vessels will become surrounded by endochondral bone, thus coming to lie in channels which are comparable to Volkmann's canals.

At this stage of development the following alterations have been completed: The crura have become hollow, osseous cylinders, cartilage and spicules of bone having been removed from their interior; the conjoined portions of the crura at the neck of the ossicle have attained similar structure; the head is composed of solid cartilage and is, therefore, the least altered portion of the stapes; the base is hollowed, its vestibular wall (the future definitive base) is thinned in the intercrural area to one-third or one-fourth the thickness of its peripheral (articular, or fenestral) portion. Within the base, on the tips of the eroded cartilage, endosteal bone is being deposited, these spicules being the fragmentary forerunners of the continuous lamina which will eventually cover the tympanic surface of the cartilage. In like manner, bone will later be deposited on the internal surface of the cartilage of the head, but only after this cylindric portion of the ossicle has become hollowed toward the obturator space. Consequently, the head will be converted into bone, except where its lateral, foveate, surface forms an articular area for the incus. Bone will be added in two ways: by growth inward from the periosteal bone which clasps the remaining, disklike piece of capital cartilage, and by deposition of islets of endochondral bone on the irregular inner surface of the articular cartilage. In the base, the process of fusion of part of the foraminous lateral wall (periosteal bone) with the bone (endosteal) deposited on the lateral surface of the basal cartilage is under way. In the current specimen, the approximation of the two osseous strata is witnessed in its initial stages. Ultimately, only the peripheral part of the foraminous periosteal bone will remain; it will sink to the level of the newly formed plate of endochondral bone which, then, has covered the internal surface of the basal layer of cartilage. Circumferential vascular spaces of the base are being formed through the inclusion of vessels between the merging periosteal and endosteal layers of bone.

The fissular channel (containing fibrous tissue) is immediately invested with a cartilaginous tube. In turn, the chondral tube is surrounded by endochondral bone and intermittent patches of intrachondrial bone, cartilage and marrow (fig. 8 *a*).

210 Mm. Fetus (23 weeks; series 51).—In this specimen there is evidenced the next important step in the process of ossification (fig. 13 *a*): The bone on the obturator portion of the crura and neck has been resorbed (figs. 2 *b*, 7 *a*); irregular ledgelike and bridgelike portions

are all that remain of the corresponding portion of the base (fig. 1 *e*). These perforated and irregular bridgelike remnants of the obturator portion of the base pass obliquely from the basal extremity of the inferior, crural margin to a corresponding position on the superior, crurobasal margin posteriorly (fig. 13 *b*). From the same (anteroinferior) crural margin a wedge-shaped fragment extends perpendicularly, to become continuous with the basal bony plate. Similar remnants, of various forms, are common in other specimens of a comparable stage of development.

This specimen represents another crucial step in stapedial development. It is advanced over the 215 mm. fetus (series 62), principally

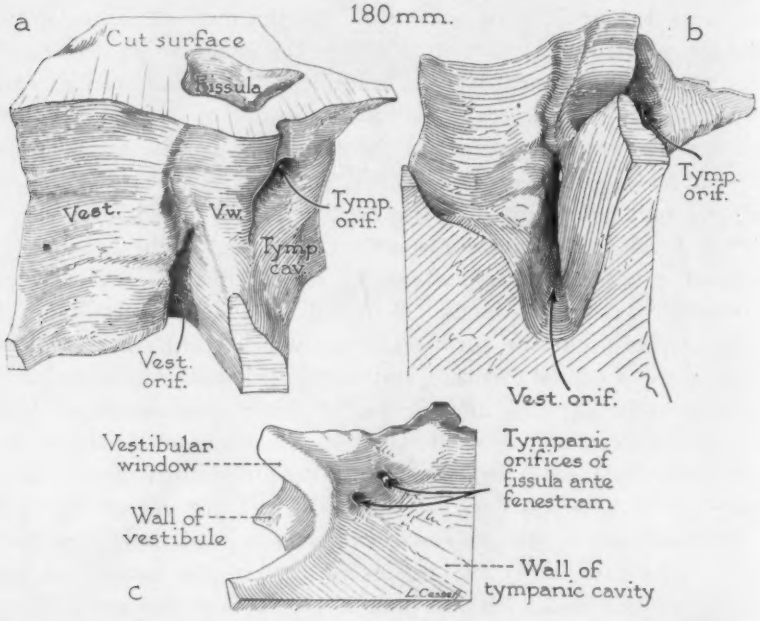

Fig. 11.—Reconstruction of the fissular region of the otic capsule in a 180 mm. (21 week) fetus (Wisconsin series 45 *b*) with stapes removed; × 7: (*a*) viewed from a posterosuperior position, that is, looking toward the anterior wall of the vestibular window and into both orifices of the fissula ante fenestram; (*b*) viewed from a posteroinferior position, looking upward into the vestibular orifice of the fissula; (*c*) viewed from a lateral (tympanic) position, looking toward the outer wall of the capsule, where occur, in this specimen, paired tympanic openings of the fissula. Part *c* is of a block less inclusive than that shown in *a* and *b*.

In this specimen the fissula is of aberrant form, being both taller and wider than usual. A cupola-like extension is prolonged cranialward beyond the horizontal level of the tympanic orifice. It contains cartilage (not represented in the reconstruction).

in respect to configuration of the crura and base. The obturator portion of crural periosteal bone has been removed, leaving open, grooved crura. Absorption has also taken place in the corresponding bone on

the basal surface; endosteal bone forms a continuous plate over the cartilage lamella of the base (fig. 1 *e*).

The fibrocartilaginous fissula is invested with endochondral bone (fig. 8 *b*). The fenestral articular cartilage forms a circumferential rim for the vestibular orifice. It is continuous across the adjacent part of the anterior wall of the vestibule with cartilage which extends for a short distance into the vestibular extremity of the fissula ante fenestram; it is no longer carried through the length of the fissula, as it was in earlier developmental stages.

215 Mm. Fetus (24 weeks; series 62).—The stapes is but slightly advanced beyond the stage of the 202 mm. fetus (series 14), and not so far advanced as that of the 205 mm. fetus (series 7) stage (compare fig. 6 *c* and *d*).

Excavation of the stapedial head has continued, leaving a wide plate of articular cartilage, internal to which are persistent spicules of endochondral bone (fig. 6 *d*). The neck and crura are completely hollowed, but they still contain marrow. Numerous foramens appear on the outer aspect of each crus; since the opposite (obturator) wall is the one which is regularly resorbed, it is probable that the existent foramens would have been obliterated in the course of later development. There is progressive resorption of bone on the obturator aspect. The interval between the thinned bony plate of the obturator surface and the adjacent basal plate of cartilage is gradually lessening, thereby bringing these laminas into closer apposition. Spicules of endochondral bone remain attached to the basal articular plate on the obturator surface of the latter. Comparable advances in osteogenesis are observed in the adjacent capsule and in the incus.

The osseous walls of the fissula face a marrow space which is decidedly fetal in character, since it possesses virtually no bone. Its vestibular orifice is continuous with a wide fenestral opening.

222 Mm. Fetus (25 weeks; series 46).—This stapes is not so far advanced as it is in the 210 mm. fetus (series 51). The base retains a residuum of fenestrated periosteal bone. This bone occurs as a plate which no longer extends uninterrupted between crura; instead, reduced in amount, it passes abruptly downward to an attachment on the newly formed lamina of endosteal bone of the base. The latter forms an almost continuous layer, independent of any contribution from the periosteal bone of earlier genesis. The crura are channeled, the facing walls being entirely removed. The capital extremity is widely excavated, leaving a broad cartilaginous (articular) plate, on the inner surface of which there is early, sparse deposition of endosteal bone (fig. 7 *b*).

230 Mm. Fetus (26 weeks; series 2).—The stapes is similar to that of the 222 mm. stage (series 46). The stapedial crura are channeled, and the marrow has been removed. The head, likewise, is hollowed; cartilage remains only on the articular aspect. At the

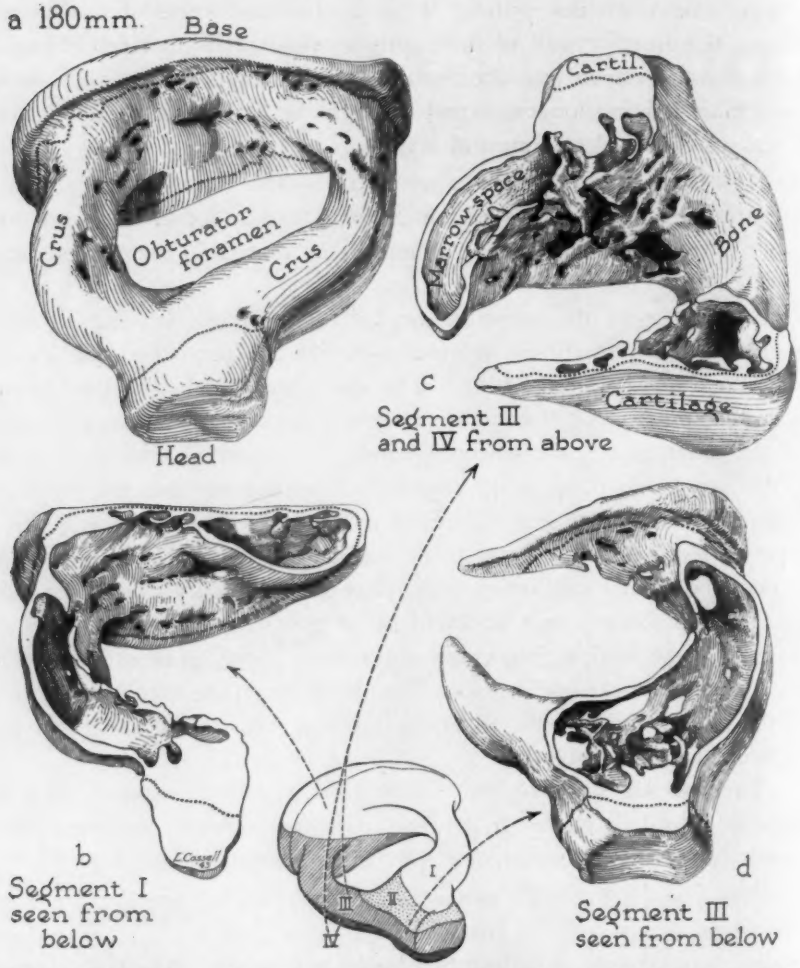

Fig. 12.—Drawings of a reconstruction of the stapes in the 180 mm. (21 week) fetus (Wisconsin series 45 *B*); × 7: (*a*) the entire stapes, in superolateral view; (*b*) segment 1 (see inset), viewed from below (that is, here inverted); (*c*) segments 2, 3 and 4 in superomedial view; (*d*) segment 3, from below (reconstruction inverted), with segment 4 removed; inset, reconstruction with segments lettered and with arrows recording the direction of view in the correspondingly lettered figures.

The drawings show the extent to which periosteal bone has been removed on the obturator surface of the base (*a* and *b*), crura and neck (*c* and *d*) and the degree to which the stapes throughout has been hollowed (*b* to *d*). Cartilage now remains only on the articular surface of the head and on the vestibular surface and fenestral margin of the base of the ossicle (*b* and *c*). The addition of endochondral bone has converted the base into a thinned bilaminar plate (*b* and *c*). Such bone appears in limited amount as spicules in the area where the crura join the neck of the stapes (*d*).

junction of crura and base, and along the basal plate, final architectural alterations are in progress; at the periphery of the crurobasal junction, bone is replacing the chondral remnant, with the formation of voluminous vascular channels; in the midportion of the base, an incomplete endosteal lamina is applied to the obturator surface of the thinned basal cartilage, especially in the crypts remaining from an earlier stage of erosion.

The fissula ante fenestram has attained adult form. At the vestibular end of the fissula, bone surrounds the connective tissue as a complete shell but is, in turn, lined by an incomplete lamina of cartilage. The vestibular extremity ascends to approach the customary site of a fenestral orifice; however, a true fenestral opening is not established, cartilage, or tissue intermediate between cartilage and perichondrium, intervening between the fissular connective tissue and the annular ligament. The tympanic extremity opens by a definite orifice into the semicanal for the tensor tympani muscle.

The bone of the fissular part of the capsule is largely intrachondrial. Marrow space outbulks bone, the bone occurring as fine spicules, sparsely distributed, some of which are directly continuous with the cartilage which surrounds the fissular connective tissue. A fissula of this type undergoes relatively little subsequent change. Once formed, the fibrocartilaginous component of the fissula remains dormant until birth; then the changes which do occur affect chiefly the bone external to that of the fissula. Only in those instances in which cartilage remains as a mass will notable fetal or postnatal modifications of fissular tissues occur.

240 Mm. Fetus (27 weeks; series 112).—In stapedial development, this series would precede the 205 mm. fetus (series 7) and follow the 210 mm. specimens (series 51 and 21); in all major otologic features the present (240 mm.) specimen resembles the 210 mm. fetus. The walls of the crura are only moderately fenestrated, but the internal (corresponding) wall of the base is rather foraminous. Although the effects of erosion are clearly evident, no osteoclasts are discoverable. The base of the stapes is bilaminar. The new bone has been applied as a thin layer to the cartilaginous lamella, but is removed by an appreciable space from the old periosteal bone. Within the space between periosteal and endosteal bone, marrow tissue still persists. A vascular mesenchyma occupies the circumstapedial "space" of the future tympanic cavity (middle ear). In the areas of implantation of the crura into the base, the bone of the remaining (external) part of the crus and that of the base are continuous, a fact whch suggests an inward spread from the periphery. In the base, the newly formed osseous layer is only one fourth as thick as the older layer of cartilage, to which it is now applied. In the peripheral part of the base, intra-

chrondrial bone occurs in association with the endochondral type. Spaces exist marginally between the bone and the cartilage where the crura meet the base; these, as already mentioned, serve for the transmission of blood vessels in adult stapes. The head is deeply excavated, there being little more of the cartilage left than would be present for articular purposes. Bone has not yet invested the internal surface.

The fenestral cartilage is separated from the capsular wall by intervening formation of periosteal bone. It is, however, continuous with a still bulky fissular cartilage. The cartilaginous portion of the fenestral rim and that of the adjacent base of the stapes are of the same hyaline structure as that of the auxiliary fenestral orifice of the fissula.

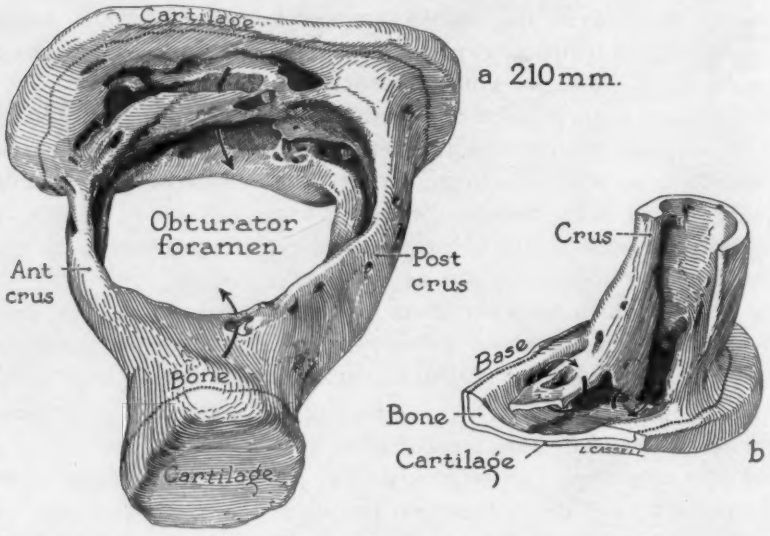

Fig. 13.—Drawings of a reconstruction of the stapes in a 210 mm. (23 week) fetus (Wisconsin series 51); × 7: (*a*) reconstruction entire, seen from a superolateral position; (*b*) basal portion of the posterior crus and the adjacent posterior third of the base, seen as though from the obturator space.

Almost all of the obturator wall has been resorbed; that portion which remains is foraminous (arrow through a foramen in *a*). The obturator surface of the base is irregularly eroded; a portion of it persists as the crista stapedis (beneath which crest an arrow passes in *a* and *b*). The cartilage which remains on the articular surface of the head is permanent (*a*); on the base not only does it cover the vestibular surface, but also is carried over the periphery of the base along the surface related to the vestibular window (*b*, at cut edge). A remnant portion of the original periosteal bone (encircled by ring in *b*) is fusing with the newly formed endochondral plate on the vestibular aspect of the base.

Periosteal bone forms the tympanic, vestibular and cochlear walls and serves as an investment for the fissular cartilage. Within the otic capsule, in the area bounded by these walls, intrachondrial and endochondral bone now are sparsely present. Subsequently, ossification will fill in the space with bone of petrous consistency. Periosteal bone,

at the anterior margin of the window, surrounds the cartilage of the auxiliary (fenestral) extremity of the fissular mass and actually invades the tympanic orifice. At the vestibular extremity the orifice is widely open, but the mass of cartilage is considerable in amount. Although thin, there is already a complete periosteal investment for the fissular cartilage, which follows the latter inward from the window toward the cochlea. In association with the peripheral portion of the cartilage, intrachondrial bone is forming. At this stage, therefore, is established the succession of tissues which becomes the regular order in the adult fissula: connective tissue (core), hyaline cartilage (investing tube) and intrachondrial islands associated with endochondral bone (general outer bed). At the tympanic extremity the succession described is repeated. In the depths of the fissula the cartilage is calcified and merges marginally wth whorls of intrachondrial bone and trabeculae of endochondral bone. Near the orifice of the fissula, cartilage passes gradually into a tissue perichondrial in nature; the perichondrium merges with the subepithelial connective tissue. Periosteal bone of the tympanic wall passes into the orifice of the fissula and is continuous with a layer of the same tissue which now almost completely surrounds the cartilage. Investment is not yet complete, since in certain small areas near the orifice the cartilage of the fissular shell is exposed to the marrow. This means that osseous encroachment at the tympanic end is an early feature of development, whereas it is a later feature at the vestibular extremity, if it ever occurs at all. This circumstance accounts for the fact that in adult specimens the wall of the tympanic portion of the fissula is osseous, while cartilage remains (albeit in the form of a thin shell) at the vestibular end. As is made clear from the study of postnatal stages, the cartilage will be subsequently reduced in bulk to the thinness of a pellicle, which in some specimens forms an incomplete investment for the fibrous tissue of the fissula. Some of the endochondral bone, which at this stage appears in association with the cartilage, will itself be replaced with bone of the primary type.

Periosteal bone now separates the cartilage which borders the space of the vestibular window from that which forms the wall of the fissular channel. Here, again, cartilage rests on bone. Some of the bone is of the intrachondrial type; it crosses beneath the attached surface of the fenestral rim, setting off the latter as a unit and completing the periosteal part of the osseous capsule. By a process similar to that which is reducing the bulk of the fissular mass, the fenestral rim will be narrowed and thinned. Deep to the periosteal layer, the endochondral bone will fill the space now occupied by primitive marrow.

240 Mm. Fetus (27 weeks; series 112).—The stapes has undergone more complete excavation of the base and complete destruction of the

obturator wall (fig. 14 *a*). However, large, irregular fragments of endochondral bone persist on the obturator aspect of the neck and within its excavated portion; a small amount of marrow is also retained in the capital space. The general proportions of the ossicle are massive (fig. 14 *b*); the bone of the crura and of the head is thick (fig. 14 *c*). The heavier bridges of bone have been removed from the base; only irregular, flattened trabeculae remain on the lateral (tympanic) surface of the base and in the area between the base and the adjacent portion of each crus (fig. 14 *b*).

246 Mm. Fetus (27½ weeks; series 30, 15).—The stapes of fetus 30 is generally similar to that of the 230 mm. specimen (series 2), whereas

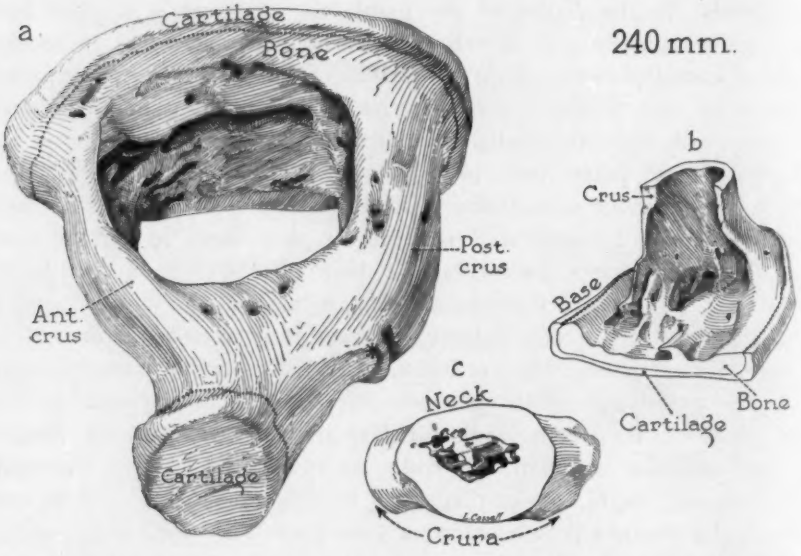

Fig. 14.—Drawings of a reconstruction of the stapes in a 240 mm. (27 week) fetus (Wisconsin series 112); × 7: (*a*) reconstruction pictured entire and viewed from a superolateral position; (*b*) the basal portion of the anterior crus and the adjacent anterior third of the base seen as though from the obturator space; (*c*) the neck of the stapes (capital portion removed) and the adjacent portions of the two crura, in lateral view. In *a* are shown the limits of the portions shown in *b* and *c*.

The crura are now channeled columns (*a* and *b*) and are foraminous in certain areas (*a*). On the base of the ossicle some of the persistent perichondrial bone has formed an incomplete crista stapedis (*a* and *b*); under arrow in (*c*). The neck and head are hollowed; yet some endochondral bone, in the form of spicules, remains to close the capital space (*c*). The stapes has assumed typical adult form: The anterior crus is the shorter and thinner of the two; a pronounced tubercle appears on the posterior crus, for attachment of the tendon of the stapedius muscle, and the head is foveate on its articular surface (*a*). The osseous lamina of the base is composed of endochondral bone, with which have fused remnants of the original perichondrial bone from the once complete obturator wall of the base (*a* and *b*). As is regularly the case, the developmental changes affecting the head of the stapes are retarded; part of the obturator wall here remains to close the capital space medially (*c*). Such bone sometimes persists in the stapes of adults, either in the form of a perforate plate or in that of osseous bridges.

in fetus 15 it is advanced beyond the stage shown in the latter. In fetus 15 endochondral bone has covered the basal plate of cartilage at the periphery in such a way as to form osseous channels, through which the blood vessels course.

265 Mm. Fetus (29 weeks; series 69).—The process of canal formation around the periphery of the stapedial base continues, with the intrachondrial bone taking part by further walling off these channels. Endochondral bone is covering the now extremely thin layer of basal cartilage.

The fissula is of unusual form in that its tympanic extremity is wider than the vestibular orifice. There is no fenestral opening, although the connective tissue within the fissular channel approaches the fenestral cartilage. At the tympanic opening the tissue is of such concentrated type as to suggest a perichondrium.

275 Mm. Fetus (30 weeks; series 4).—The stapes is essentially of adult form (fig. 15 *a*). The head is now an osseous cylinder capped by a plate of articular cartilage. Its surface is irregular outside and inside, and in the latter situation the irregularities represent openings of vascular spaces, some of which are continued into the crura. The medial (obturator) end of the capital cylinder is crossed by a ledge of bone (figs. *7 c*, 15 *b*) similar to that seen not only in some early postnatal stages but also in adult specimens. The crura are channeled, thinned and bowed and are now invested on all aspects with mucous membrane. The base is bilaminar and is canalized peripherally; the vessels within the canals communicate with those of the newly formed connective tissue. Marrow tissue has not been entirely removed, however; some remains in the head and neck. In general, the irregularities characteristic of the stapes in earlier stages of development have been smoothed out. There is further flattening of the trabeculae on the tympanic (lateral) aspect of the base. The vestibular (medial) surface of the base is smooth and reniform (fig. 15 *c*).

290 Mm. Fetus (32 weeks; series 66).—A slight amount of marrow persists in the head of the stapes despite the fact that a ledge, such as that described in the preceding stage, is wanting in this specimen. Bone is present on the medial (internal, or obturator) aspect of the articular cartilage (fig. *7 d*). The channeled crura are thinned and are invested with mucous membrane. The base is thin and bilaminar. The marginal spaces, formed by the fusion application of the persistent portion of the periosteal bone with the adjacent endosteal bone, are striking morphologic features (figs. 1 *f*, *7 d*). In being less massive than the stapes in the 275 mm. stage (series 4), and in the absence of the cervical obturator plate (to leave an open, marrow-free capital extremity), the ossicle of the 290 mm. fetus has attained adult form.

The presence of marrow in the capital part represents the sole fetal feature.

Bone has filled the spaces which formerly existed in the area bounded by tympanic, cochlear and vestibular walls, a circumstance which renders the fissular tract inconspicuous. In this way the fissular region of the capsule assumes the appearance of compactness; consequently, it may, for the first time, be described as petrous. The fissula is of simplest type; it is short, slightly broadened in the part between two orifices, and contains a fibrous core around which cartilage forms an incomplete shell. The latter is thin where present, and the bordering bone is largely of endochondral type. A fenestral orifice is represented

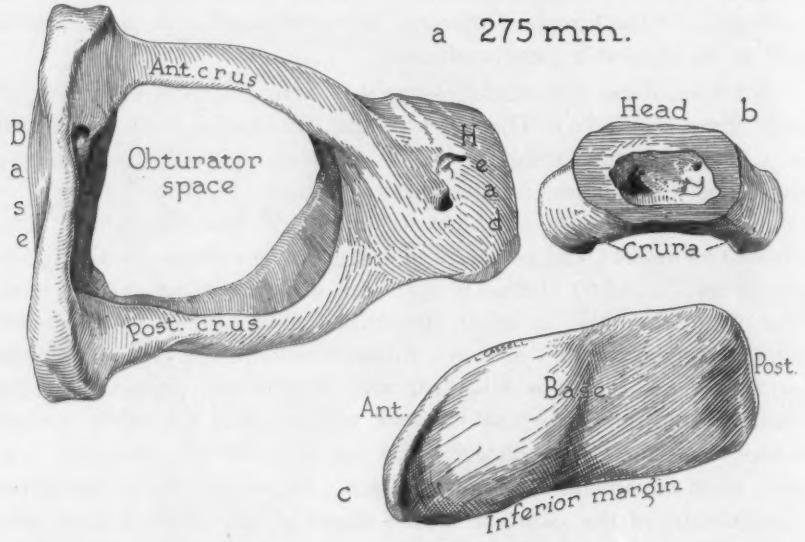

Fig. 15.—Drawings of a reconstruction of the stapes in a 275 mm. (30 week) fetus (Wisconsin series 4); × 7: (*a*) the reconstruction entire, viewed from above (superior, or cranial, aspect); (*b*) the neck and adjacent portions of the crura, in lateral (tympanic) view; (*c*) the base of the ossicle seen in medial (vestibular) view.

The stapes has attained adult form; of the crura, now deeply channeled, the posterior is longer and larger (*a*); the base is flatter on the posterior than on the anterior margin (*c*); the head and neck are hollowed (*b*). In this fetal specimen, as in some adult ossicles, a ledge of bone partially closes the space of the neck toward the obturator foramen.

by a shallow cleft which opens on the anterior surface of the vestibular window. This orifice is surrounded by an irregular mass of cartilage which is continuous with that of the articular margin (fig. 8 *c*).

295 Mm. Fetus (33 weeks; series 20).—The stapes is now snugly invested with mucous membrane, continuous with that on the adjacent tympanic wall. The abundant blood vessels in the lamina propria are unusually clear.

The connective tissue which fills the fissular channel is slight in amount and contains but few small vessels; the vertical distance between the cranial border of the vestibular orifice and the small tympanic opening is slight. The immediately investing wall is composed of cartilage and perichondrium, external to which are situated areas of endochondral and intrachondrial bone. This is equivalent to saying that the fissula and the related area are, respectively, of adult form and of mature histologic structure.

305 Mm. Fetus (34 weeks; series 60 A).—The stapedial structure is substantially that of the ossicle in the term fetus (to be described later).

345 Mm. Fetus (38 weeks; series 61).—The stapes is indistinguishable from that of the postnatal stages (fig. 7 *e*). Bone covers the inner surface of both capital and basal cartilages. The base is thinner than it was at any preceding stage of development; cartilage comprises approximately two thirds, and bone one third, of the thickness. The mucous membrane, which has replaced marrow, extends inward to invest the former endosteal surface of the head.

The fissular part of the capsule is similar to that encountered in the ear of an adult. An auxiliary (fenestral) orifice is present. The vestibular orifice of the fissula is a narrow cleft; the tympanic opening is small and virtually circular. The channel retains a thin wall of cartilage (fig. 8 *d*). The capsular bone is of dense, compact type; spaces are few and small.

363 Mm. Fetus (40 weeks; series 16).—The stapes is of adult form. The thin, bilaminar base is vascularized circumferentially. The head is hollowed, and its articular portion is bilaminar. The crura are exceedingly thin.

The small fissula is of typical form in its lower part but is aberrant cranially in lacking a tympanic opening. The vestibular opening crosses obliquely to the window, producing an uninterrupted vestibulotympanic cleft.

Term Fetuses (series 67, 127, 95, 102 and 115).—In fetus 67 the internal surface of the head of the stapes is extremely irregular, being sulcate for the transmission of blood vessels. The external surface is also somewhat irregular. The crura are strikingly thinned; as a consequence, they are indistinguishable from those of an adult ossicle. The base, like the head of the ossicle, is bilaminar and thin.

In sections, the fissula appears as a narrow fibrous seam, clearly traceable from the vestibular to the fenestral opening. However, near the tympanic orifice the fibrous tissue passes into the surrounding cartilage by such imperceptible gradation that the former tissue seems to be wanting. As a result, the tympanic opening of the fissular channel is inconspicuous.

Beneath the thin periosteal shell the capsule is well filled with endochondral bone; marrow spaces occupy less than one fourth of the entire fissular portion of the otic capsule.

In fetus 127 the stapes is of adult form. The base, crura and head have been excavated and hollowed to striking thinness. Submucosal vessels are now prominent; marrow has disappeared.

Cartilage is minimal in amount on the fissular wall, being present as a distinct layer only at the vestibular end. The surrounding bone is chiefly endochondral, with some intrachondrial bone deeply embedded in its substance. There is no fenestral orifice. The small tympanic opening of the fissula ante fenestram is situated posterior to the develop-

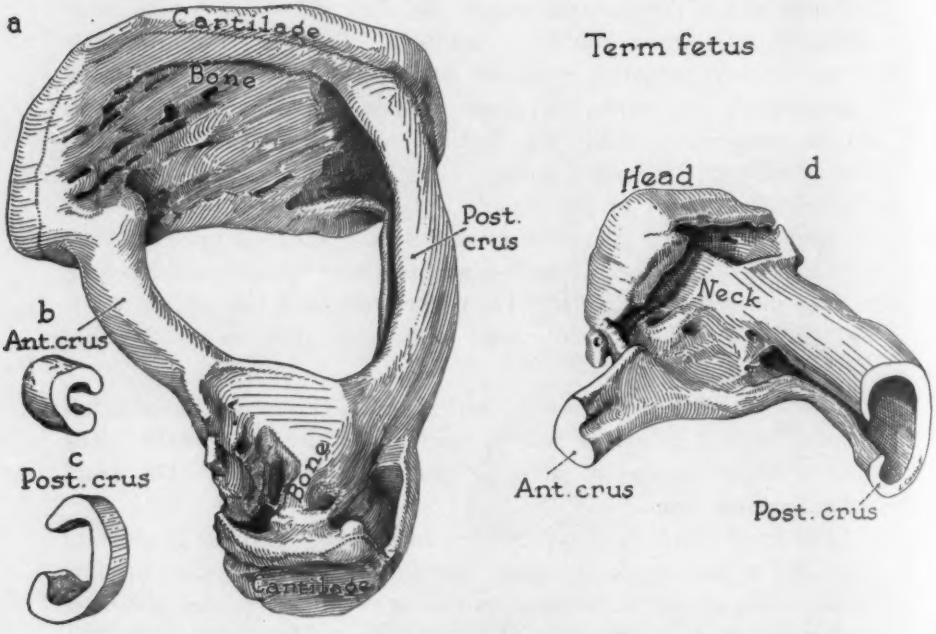

Fig. 16.—Drawings of a reconstruction of the stapes in a fetus at term (Wisconsin series 102); × 7: (*a*) the reconstruction entire, seen from a superolateral position; (*b*) segment of anterior crus; (*c*) segment of posterior crus; (*d*) lateral part of the reconstruction in posteromedial view. In *a* are indicated the limits of the segments shown in *b* and *c*.

The cartilage which covers the vestibular (medial) surface of the base is carried over the fenestral margin as a circumferential lip, while the tympanic (lateral) surface is formed by a plate of irregular bone which is composed of both endochondral and perichondrial bone (*a*; cf. figs. 13*a* and 14*a*). The crura are deeply channeled (16*a* to *c*). The head and neck of the ossicle are strikingly eroded, despite the fact that the cavity of the capital portion is crossed by a plate of bone (*a* and *d*). This feature of sculpturing is persistent, being encountered in ossicles from adults (specimens from a 57 year old person and from other adults). The anterior crus, much the slenderer and shorter of the crura, is implanted in the base at the inferior margin of the crus (*a*); at the point of continuity with the head, the crus flattens to meet the intercrural plate (*d*). The bulkier posterior crus is implanted widely into its portion of the base (*a*); its cavity, relatively capacious (*c*), opens into that of the head and neck by a small orifice (*d*). Cartilage covers the articular surface of the head as a layer of restricted extent (*a*).

ing semicanal of the tensor tympani muscle. Altogether, the fissula may be said to be of the kind previously described as typical.

There is a sharp line of demarcation between the bone of the original capsule and that added in later development. Marrow spaces of fair size occur only in the area midway between the tympanic and the cochlear wall. This is the site of the space which originally contained only intrachondrial bone and marrow (compare the 230 mm. fetus, series 2).

In fetus 95 the stapes is again of adult type. The vestibular orifice of the fissula is of conventional form. Its connective tissue core is uninterrupted. The fibrous tissue extends into a small, but definite, fenestral orifice, whose walls are formed by the cartilaginous tissue of the fenestral rim. The tympanic extremity is aberrant in being occupied by a cartilaginous nodule without fibrous content. The nodule touches, but remains covered with, a thin part of the periosteal tympanic wall; the area on which it tends to open is that of the semicanal.

In fetus 102 the stapes in all respects is, again, an adult ossicle (fig. 16*a* to *d*). The vestibular and fenestral orifices of the fissula are of typical form and size. The tympanic orifice is indistinct, since in the cranial part of its extent the meager connective tissue is displaced by a concentrated tissue which resembles a perichondrium. The occurrence of such tissue is of interest in connection with the formation of cartilaginous nodules in the cranial part of the fissular tract.[4] It is evident that new cartilage, formed from the usually dormant lining of the fissula, may spread to obliterate the normal fibrous tissue of the fissular canal.[5] Subsequently, the cartilage is likely to ossify. In the current specimen such a change was doubtless in progress, since the peripheral part of the perichondrium-like tissue gradually merges with the bone.

In fetus 115 the stapes is of an adult form except for the presence of a ledge on the interior of the head. The ledge corresponds to the partition seen in the 275 mm. specimen (series 4). In certain portions of the base the osseous lamina is thicker than the cartilaginous, a proportion which we formerly believed obtained only in adult stages.

The fissula is of the typical variety. It is thin mediolaterally; its content is fibrous. The vestibular and tympanic orifices are narrow; an auxiliary (fenestral) opening is wanting. The capsule is well filled in with endochondral bone, marrow spaces being large only in

4. Bast, T. H.: III. Development of Otic Capsule: Fetal and Infantile Changes in Fissular Region and Their Probable Relationship to Formation of Otosclerotic Foci, Arch. Otolaryng. **23**:509-525 (May) 1936.

5. Anson, B. J.; Cauldwell, E. W., and Bast, T. H.: Ann. Otol., Rhin. & Laryng. **57**:103-128, 1948.

a line corresponding to that of the junction of the early capsule and the newly added shell of periosteal bone.

In general, it may be said that the stapes of the fetus at term is extensively excavated throughout its obturator aspect. The superior portion of the anterior basocrural junction is decidedly attenuated. The diameter of the anterior crus is approximately one-half that of the posterior crus. The superior surface of the crurocervical region is likely to be more irregular than the inferior. Ledges of bone are likely to persist on the inner surface of the head and base.

Newborn (series 315).—In the newborn the stapes is of fully mature form and structure (fig. 8*e*).[6] The fissula ante fenestram extends toward the fenestral margin, but does not communicate with the vestibular window (compare 345 mm. stage, series 61). The capsule is compact, its relatively petrous nature suggesting the texture of the adult capsule.

SUMMARY

Ossification has been initiated in the stapes of the 150 mm. fetus. The process begins in a solitary center on the obturator surface of the base. However, in a fetus at the 160 mm. stage, bone development is relatively tardy. Encroachment from the single center to the cruro-basal cartilage is in evidence in the 163 and 175 mm. stages; erosion and calcification of cartilage is well advanced in the 160 mm. stage. In the 170 mm. fetus periosteal bone surrounds the anterior crus, extending from the base to the future neck of the stapes. The crura are converted into hollowed cylinders in the 190 and 202 mm. fetuses; concurrently, calcification of cartilage in the neck is under way, in anticipation of the spread of bone across the crural junction. In the 180 mm. fetus, and its developmental counterpart, the 205 mm. stage, this junction has been effected; through this fusion the obturator wall is formed circumferentially of foraminous periosteal bone; spicules of calcified cartilage and intrachondrial bone persist in the cervical and

6. For the reader who may be interested in the form of the adult stapes and in that of embryonic, fetal and infantile stages in its morphogenesis, figures of reconstructions are available in three of the four antecedent contributions published in this journal (Anson, Karabin and Martin.[1] Anson, B. J., and Cauldwell, E. W.: Stapes, Fissula Ante Fenestram and Associated Structures in Man: IV. From Fetuses 75 to 150 Mm. in Length, ibid. **37**:650-671 [May] 1943). These stages, in the order of age, are as follows: 22.8 mm. (7½ weeks); 25 mm. (8 weeks); 29 mm. (8½ weeks); 40 mm. (10 weeks); 50 mm. (11 weeks); 78 mm. (13 weeks); 100 mm. (15½ weeks); 111 mm. (16½ weeks); 126 mm. (18 weeks); 135 mm. (17 weeks); 150 mm. (20 weeks); 161 mm. (19½ weeks); 183 mm. (21 weeks); term fetus; infant of 3 months; child of 3 years; adult of 18 years; adult of 57 years; adult of 70 years. These may be interpolated in, or added to, the group of reconstructions pictured in the current article.

basal portions. Erosion of the capital cartilage is advanced in the 215 mm. stage; absorption of the basal obturator plate has progressed further, thereby enlarging the irregularly distributed foramens. This process is approaching completion at the 222 and 210 mm. stages, leaving articular cartilage at the capital extremity and an irregularly thickened basal cartilage. While resorption of the periosteal bone on the obturator wall of the base is progressing, this "roof" of the basal space is gradually approximated to the tympanic portion, or "floor." Concomitantly, resorption of the corresponding portions of the crural wall has produced incomplete channeling of the limbs, a change which suggests the adult form. At this stage, bone is generally of coarse fibrillar type; however, maturation is evident at the capitocrural junction.

The entire obturator portion of the foraminous periosteal bone has been removed in the head and the crura of the stapes at the 245 mm. stage; in the base the original periosteal bone persists only as marginal elevations and as an inconstant central crista. The articular surface of the head is now bilaminar, since the cartilaginous plate has been completely lined with endochondral bone. The stapes at the 275 mm. stage is of massive proportions, with the persistence of a bony ledge on the obturator surface of the neck. At the 290 mm. stage the osseous stapes is approaching definitive proportions. Further modeling contributes to the stapes at the 345 mm. stage the histologic structure and general conformation of the postnatal ossicle. The stapes of the fetus at term is indistinguishable from that of an adult.

The transition of a fibrous seam in the primordial fissula ante fenestram into cartilage with realteration of the surrounding capsular tissue advances on a variable growth gradient, now showing a mature fissular zone at the early fetal stage, again persisting as a primitive stripe late into fetal life. An auxiliary orifice occasionally opens on the fenestral margins, and in some cases the fissular orifice is an open cleft extending continuously from the tympanic, through the fenestral, to the vestibular surface of the otic capsule. Rarely is the tympanic orifice lacking.

At the 160 and 179 mm. stage the fissula is merely a fibrous seam in a cartilaginous capsular mass. Broadening of the fibrous component, with early vascularization, occurs in a 170 mm. fetus. Gradual erosion of the surrounding cartilaginous mass leads to isolation of the fissula from the cochlear portion of the capsule; this process can be traced successively through the 170, 175, 202 and 167 mm. stages. Persistent fissular cartilage undergoes transitional change into calcified cartilage (170 mm.), then into intrachondrial bone (167, 190 and 193 mm.) and, finally, into endochondral bone (180 and 205 mm.), with concurrent reduction

of adjacent primitive marrow spaces. At the 210 mm. stage the fibrocartilaginous fissula is invested with endochondral bone, cartilage persisting only at the vestibular orifice. The fissula of the 230 mm. fetus resembles that of the term fetus; it will undergo little intrinsic reorganization; subsequent changes will be predominantly extrafissular, serving to remodel the adjacent capsule. At the 265 mm. stage, the fibrous fissula is bordered chiefly by intrachondrial and endochondral bone. These osseous elements become abundant enough to render the fissula at the 290 mm. stage an inconspicuous stripe. Thereafter, at the 295, 345, 363 and 370 mm. stages the fissula is of stabilized, "adult" type, resembling that of the infant at term.

The perifissular cartilaginous mass, continuous with that of the cochlea anteriorly and the fenestral rim posteriorly, undergoes gradual resorption and replacement by a series of intermediate tissues. Calcification and formation of intrachondrial and endochondral bone occur on the lateral and medial aspects of the fissula, leaving cartilaginous continuity with the tympanic and vestibular orifices, respectively. Subsequently, separation from the cochlear cartilage is effected. Continuity with the margin of the vestibular (oval) window persists, especially in the presence of a separate auxiliary (or fenestral) fissular orifice.

At the 180 mm. stage, cartilaginous orifices are in contact with capsular periosteal bone, the latter gradually encroaching on the vestibular extremity (193 mm.). Ossification of the orifice is effected at the 230 mm. stage, isolating the fissula from cartilaginous contact with the fenestral margin. Periosteal bone then enters the fissular orifices to merge with the endochondral layer surrounding the fissular cartilage (240 mm.). Thereafter, similar osseous relations are preserved to the postnatal stage, with the exception of those stages at which the fissular continuity is maintained with the fenestral margin. In such instances the endochondral investment of the fenestral orifice establishes contact with the periosteal bone adjacent to the fenestral articular rim.

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BENIGN CYSTS OF SUPERIOR MAXILLA WITH SPECIAL REFERENCE TO CYSTS OF MAXILLARY SINUS

Clinicopathologic Study of Thirty Cases

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LOS ANGELES

CYSTS of the superior maxilla occur with a greater frequency than one is ordinarily aware of. This fact came to my attention when over a comparatively short period several patients with dental cysts of the maxillary sinus presented themselves for treatment. This series of events prompted a review of the cases in which radical operation on the maxillary sinus had been performed at the White Memorial Hospital since 1938. While discussing these cases from time to time with various colleagues, I realized that an inadequate understanding existed in the minds of at least some. For this reason, in spite of the numerous references in the medical literature available in the last few decades regarding certain of these cysts, and recent original investigations on other types, it seemed justifiable to report a few of these cases with a review of the clinicopathologic characteristics of various types of cysts occurring in the superior maxilla. Included in this report is the account of a case of traumatic osseous cyst of the superior maxilla. A similar case was not found previously reported in the literature.

A review of 48 selected cases involving radical surgical procedures on the maxillary sinus performed at the White Memorial Hospital since 1938 revealed 27 in which the operation had been for some type of cyst. In 24 of these cases the cyst had been found in the maxillary sinus and in 3 in the bony palate adjacent to the sinus. Two other cases in which operation was refused are included in this survey. A case in which operation was done at the United States Naval Hospital, Long Beach, Calif., is also presented.

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Various classifications of cysts have been proposed; but for this study the following original classification is presented:

1. Cysts of nondental origin
   (*a*) Retention cysts (secreting cysts)
   (*b*) Nonsecreting cysts of the sinal mucosa
   (*c*) Mucocele
   (*d*) Traumatic bone cysts
2. Cysts of dental origin
   (*a*) Follicular (dentigerous) cysts
   (*b*) Radicular (root) cysts
3. Cysts of nondental origin developing from defects in embryonic life
   (*a*) Median anterior maxillary cysts
   (*b*) Facial cleft cysts

CYSTS OF NONDENTAL ORIGIN

Retention Cysts.—Hajek [1] stated that in most cases of chronic inflammation of the mucous membrane in which cicatricial changes occur, one or more cysts may be found. Usually they are miliary and scattered, but occasionally a cyst may become larger than a hazelnut. Their development occurs because of cicatricial narrowing of glandular outlets, and, because of retained secretion, they may form in the alveoli or ducts of the glands. Their lining is usually ciliated columnar epithelium.

Skillern [2] divided cysts of the maxillary sinus into two classes: namely, mucoid, or retention, cysts, and dentigerous cysts. Mucoid cysts may be single or multiple and may vary from the size of a millet seed to that of a walnut. They occur because of obstruction of glandular ducts. Previous sinusitis is not essential. Skillern said that symptoms rarely occur and that these cysts are most frequently observed at autopsy.

Tunis [3] in 1910 studied the sinuses in 100 unselected heads shortly after death and found retention cysts in 13 per cent. He was convinced that such cysts are formed from the dilated duct of a mucous gland. He described the mechanism step by step in his paper and stated the opinion that these cysts are likely to be associated with atrophic inflammatory conditions in the sinus lining. These cysts rarely produce deformity. Hardy,[4] in his series, reported a case of a retention cyst which filled the left maxillary sinus and caused external deformity, with swelling of the cheek and a palpable mass over the sinus and the upper fornix of the buccal cavity.

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1. Hajek, M.: Pathology and Treatment of the Inflammatory Diseases of the Nasal Accessory Sinuses, translated and edited by J. D. Heitger and F. K. Hansel, ed. 5, St. Louis, C. V. Mosby Company, 1926, vol. 1, p. 178.

2. Skillern, R. H.: The Catarrhal and Suppurative Diseases of the Accessory Sinuses of the Nose, ed. 4, Philadelphia, J. B. Lippincott Company, 1923, p. 130.

3. Tunis, T.: Inflammation of the Sinus Maxillaris with Special Reference to Empyema: The Surgical Pathology, Diagnosis and Treatment, Laryngoscope **20**:931-976 (Oct.) 1910.

4. Hardy, G.: Benign Cysts of the Antrum, Ann. Otol., Rhin. & Laryng. **48**: 649-657 (Sept.) 1939.

The cyst may contain a thin, serous fluid or thick mucoid material. It is usually associated with hyperplastic changes and a thickened lining of the sinus. It may exist without noticeable local or general symptoms and be discovered on routine roentgenologic examination or at autopsy. Vague local symptoms may be present, or there may be troublesome constitutional symptoms, usually attributed to a focus of infection.

There were 6 cases of retention cyst in the maxillary sinus in the present series. Four of the patients were women and 2 were men. They ranged in age from 42 to 55 years, with the exception of a patient aged 19. In all cases, diagnosis was made by transillumination and roentgenologic study. In only 3 cases were there local symptoms referable to the sinuses. In 1 case the gross appearance of the sinus lining was normal except at the point of origin of the cyst. In all the others the mucosa showed varying degrees of hyperplasia and degeneration. The contents of 1 cyst were thick, like putty or cheese, but those of the others were mucoid or mucopurulent. In 5 cases there were multiple cysts, while in the sixth case the cyst was single.

A report of a representative case follows.

CASE 1.—M. P., a woman aged 55, had as chief complaints frequent colds, with occasional sore throat, and a postnasal discharge of eight to ten months' duration. She also had had pains in the left side of her chest and down the left arm and bitemporal headaches. The medical examination had established a diagnosis of arthritis of the upper portion of the spine. The patient had been given a preparation of the vitamin B complex. Recently she had also had one attack of vertigo, lasting three days, during which time she had been confined to bed, being able to lie on her right side only without severe vertigo. Rhinologic examination showed clouding of the left maxillary sinus, as seen by transillumination, pus in the left side of the nose, with moderate hyperplasia of the mucous membrane, and postnasal mucopurulent discharge. Roentgenograms of the sinuses revealed a large polypoid or cystlike mass in the upper portion of the left antrum. A radical operation on the maxillary sinus, performed through the canine fossa, revealed a pedunculated polypoid cyst suspended from the anterolateral wall. A smaller cyst was attached below on the anterior wall. These cysts contained yellowish mucoid material. Cultures yielded a growth of hemolytic streptococci. Microscopic examination showed that each growth had the characteristics of a retention cyst, with marked inflammatory changes in its walls, including cellular infiltration and distended mucous glands. Postoperative recovery was uneventful, and the patient's general condition improved. One year later she reported that she was feeling well and had not returned to the clinic for several months.

Nonsecreting Cysts of the Sinus Mucosa.—McGregor [5] discussed these cysts and explained their development in the connective tissue stroma of the mucous membrane as due to edematous distention of the tissue spaces. Their walls are formed by the crowding and packing of the connective tissue strands as the cyst enlarges. There is no

5. McGregor, G. W.: The Formation and Histologic Structure of Cysts of the Maxillary Sinus, Arch. Otolaryng. 8:505-519 (Nov.) 1928.

epithelial or mesothelial lining. Lindsay [6] showed that the fluid contents of these cysts must be considered an inflammatory exudate. He stressed the importance of these cysts in relation to focal infection and presented several reports of cases which demonstrated the tendency of the cysts to produce constitutional symptoms, such as fatigue, irritability, headaches, low grade fever, mild dizziness and pains in joints.

Grossly, the cyst contains a clear, thin, amber fluid which coagulates after removal. It does not cause deformity. The wall is thin and translucent and does not show on transillumination. Roentgenologic examination is necessary for diagnosis, which may often be confirmed by puncture of the antrum through the inferior meatus. A thin, amber fluid will drip from the end of the cannula and will coagulate when allowed to stand. Microscopic examination shows that the sinus membrane is covered with the usual epithelium of the respiratory tract. The stroma of the walls presents varying degrees of inflammatory reaction and edema. The lining of the cyst wall is composed only of a zone of connective tissue, more closely packed than most of the stroma, with no epithelial lining.

Treatment consists in obliterating the cyst. This may be accomplished by rupturing or destroying its wall. Simple lavage of the antrum by way of the inferior meatus may be sufficient to rupture the wall and allow the cyst to collapse and heal. In most cases treatment can be satisfactorily carried out through a window in the inferior meatus. Only cysts studied by an opening through the canine fossa were included in this series.

There were 5 such cysts. All the patients were women and the ages varied from 17 to 60. Each presented certain symptoms referable to the nose or sinuses, such as nasal obstruction, postnasal discharge, sensation of pressure, vague sinus pains and symptoms of vasomotor rhinitis. Other symptoms, remote to the nose and sinuses, included cough, mild asthmatic attacks, vague headaches in the occipital, parietal and frontal areas, dermatitis of the hands and feet and multiple arthritis.

The following cases are reported to represent this group:

CASE 2.—L. H., a girl aged 17, had suffered an automobile accident six years before, resulting in nasal and septal deformity with decided obstruction. For a few weeks preceding her admission there had been slight discomfort and tenderness over the left cheek. There were no other local or general symptoms, but the patient requested rhinoplasty for cosmetic reasons. Inasmuch as cosmetic improvement would also insure definite improvement of function and the establishment of a normal physiologic state, the operation was agreed to. A preliminary submucous resection of the nasal septum was performed. Roentgenograms (fig. 1) showed a rounded increase in density in the lower portion of the left antrum, sug-

6. Lindsay, J. R.: Nonsecreting Cysts of the Maxillary Sinus Mucosa, Laryngoscope **52**:84-100 (Feb.) 1942.

gestive of a cyst. This had not been detected by transillumination. The sinus was entered for lavage with a straight needle through the inferior meatus, and several cubic centimeters of clear, amber fluid was aspirated. Exploration of the antrum by the Caldwell-Luc approach was later performed. In the floor of the sinus was a partially collapsed, thin-walled, translucent cyst. When an attempt was made to remove it intact with the sinus lining, it seemed to disintegrate and could not be distinguished from the thin sinus membrane, which was removed. A large window was made in the inferior meatus. After operation there was a severe secondary infection of this antrum, with drainage of heavy, foul pus, and frequent irrigations were required for several weeks before it finally cleared. Because of this infection, the rhinoplasty was postponed for six months. Microscopic sections of this thin membrane showed ciliated columnar epithelium, but beneath the epithelium the stroma showed an increased density and infiltration with lymphocytes and plasma cells. This dense layer of stroma formed the lining of the cyst.

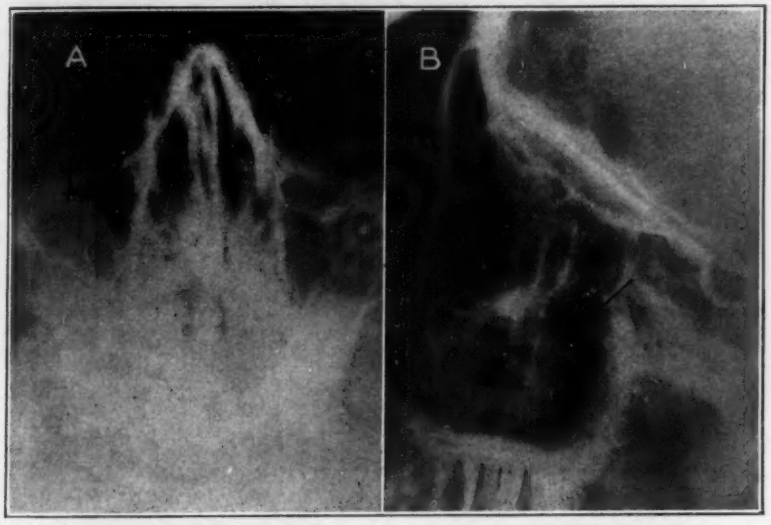

Fig. 1.—A nonsecreting cyst of the left maxillary sinus.

CASE 3.—R. S., a woman aged 31, had the following chief complaints: (1) "hay fever" for three years; (2) persistent rhinitis, with a copious watery discharge from the nose, for one year; (3) pains in the nose and cheeks for several weeks, and (4) dermatitis, chiefly of the hands and feet, for eight months. The patient had been under care for several weeks before coming to the otolaryngologic clinic. The dermatitis consisted of vesicles, which would be followed by mild exfoliation. There were also dryness and cracking of the skin of the palms. This condition resisted treatment with ointments, wet dressings and roentgen radiation. Recently the patient had experienced a sense of fulness or pressure in the left side of the maxilla, which sensation had been relieved after a few days when the patient had felt "something break" and when a large amount of yellowish fluid had escaped from the left nostril. The blood pressure was 106 systolic and 60 diastolic, and the pulse rate was 72. Serologic tests gave negative reactions. The basal metabolic rate was +8 per cent. The blood count was normal. Scratch

tests for pollens and epidermal allergens produced no reactions. Nasal findings were essentially normal. Transillumination of the sinuses showed them to be clear. Roentgenograms showed a rounded density in the floor of the left antrum. The extent of this was clearly defined by further roentgenologic study after the instillation of iodized oil U. S. P. (fig. 2). Antral puncture revealed nothing abnormal. A radical operation was done on the left maxillary sinus, exposing the dome of a thin-walled, bluish, translucent cyst filling the lower portion of the sinus. When an attempt was made to remove this cyst, it collapsed, and its wall could no longer be distinguished from the sinus lining, which was then removed. Microscopic examination showed ciliated columnar epithelium with a thin, delicate stroma. The patient experienced an acute exacerbation of the dermatitis about one week after operation. The sinus healed normally, with only slight secondary infection. The patient's last visit to the clinic was about two months later, when she reported general improvement and complete surgical recovery.

CASE 4.—J. M., a woman aged 60, complained that she had had throbbing and fulness in the right upper molar area for about three years. Removal of two molar and two bicuspid teeth in that area had failed to relieve her. She also had had

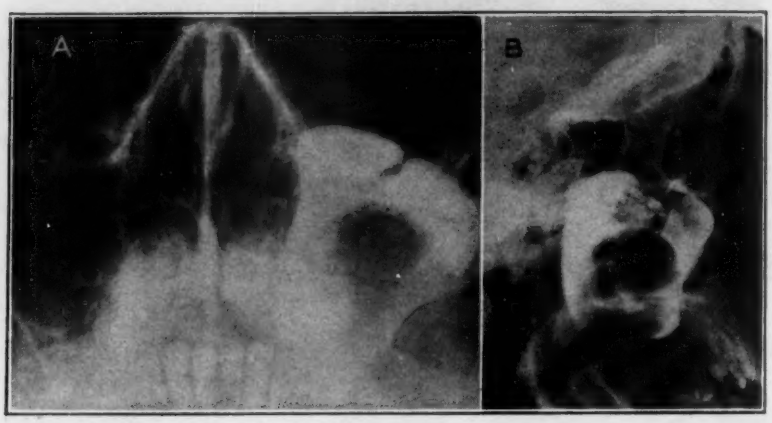

Fig. 2.—A cyst of the antrum, brought into contrast by the use of radiopaque oil.

mucopurulent nasal and postnasal discharge with repeated episodes of folliculitis of the nasal vestibule. She felt exhausted continually and had arthritis of many joints, especially troublesome in the spine. Examination revealed mucoid secretion in the right nasal passage and pus in the right tonsil, and the sinuses were clear on transillumination. Roentgenologic examination showed a rounded shadow in the floor of the right maxillary sinus. A Caldwell-Luc operation was performed, and two thin-walled cysts were found in the lower part of the sinus. Since the upper portion of the lining appeared normal, only the lower half was removed. Both cysts collapsed as they were removed, and their walls seemed to be an integral part of the sinus lining. Microscopically, the membrane was covered by columnar epithelium on one surface and a zone of compressed connective tissue on the other. Several days after surgical intervention, the patient had an acute exacerbation of the arthritis of her spine and joints of the extremities and was confined to bed for about two weeks. For several weeks after operation she complained of pain over the right molar area. There was also some mucopurulent nasal discharge.

Antroscopic examination two months later showed apparent regeneration of the sinus membrane, with some hyperplasia. Conservative therapy was continued, and gradual improvement was noticed.

CASE 5.—A. G., a woman aged 42, gave as her chief complaints frequent colds, postnasal discharge, itching of the nose and ears and the sensation of an obstructing mass in the right nasal passage for one week. The blood pressure was 138 systolic and 80 diastolic. There were large polypi in the right nasal passage, which were removed in the clinic. Transillumination showed clear sinuses. Roentgenograms showed diffuse clouding of the right maxillary sinus and a shadow with a definite border, suggestive of a cyst. An antrum needle was inserted through the inferior meatus, and yellow fluid, about 6 to 8 cc., immediately dropped from the needle.

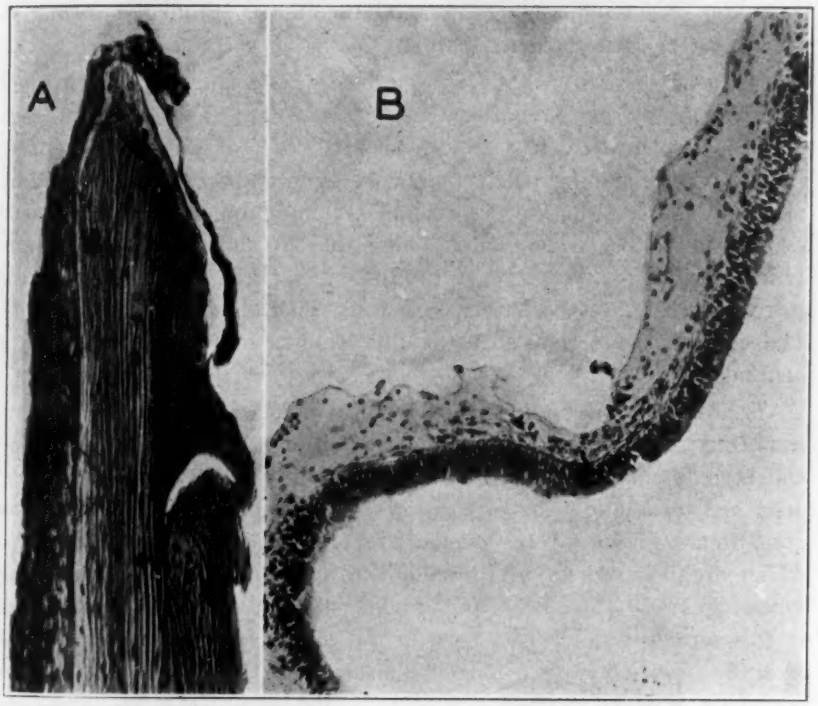

Fig. 3.—*A*, a thin piece of bone attached to a cyst and covered with periosteum; *B*, wall of the cyst.

This fluid coagulated after ten minutes. The antrum was irrigated through the same needle without appreciable resistance, and no further contents were obtained. At operation, eighteen days later, the antrum was entered via the canine fossa, this approach making visible the dome of a cyst filling the lower half of the sinus. The cyst seemed to be attached at the lower lateral wall to a small shell of bone, 8 mm. in diameter. This thin piece of bone seemed to be lying in the sinus, rather loosely attached. The cyst and the piece of bone were removed complete except for some of the fluid contents, which escaped. The sinus lining was not removed, as it appeared to be normal. Microscopic examination of the cyst wall showed a fibrous stroma with leukocytic infiltration. Some fields contained giant cells of

the foreign body type, and there was some tendency to polypoid formation. The epithelium was of the columnar type. A section cut across the edge of the piece of bone showed a thin, fibrous layer of periosteum passing continuously around its edge (fig. 3). The patient's recovery was uneventful, and she was last seen in the clinic about six weeks after the operation.

Comment on Case 5.—I have been unable definitely to classify this cyst. The small shell of bone suggests a relation to odontoma, but the patient gave no corresponding history or findings of dental abnormalities. The epithelium was suggestive rather of a retention cyst. The fluid contents grossly resembled and behaved like those of the nonsecreting cysts. It is possible that the shell of bone was a sequestrum, either traumatic or inflammatory. It could then have stimulated formation of the cyst by irritation, as a foreign body.

Mucocele.—Hardy stated that the terms cysts and mucocele are not synonymous. Microscopically these growths are the same and each would be diagnosed as cyst, but the diagnosis of mucocele is made grossly on the finding of thick mucoid or gelatinous material within. Skillern described the mucocele as an accumulation of mucoid material in the sinus, this accumulation being due to closure of the ostium. This description corresponds to that given by Hajek for hydrops of the antrum except that the latter has serous, instead of mucous, contents. The conclusion, therefore, that a mucocele is not a true cyst seems justifiable.

Traumatic Bone Cysts.—Boyd [7] stated that a hematoma in the subcutaneous tissues may, instead of being absorbed, undergo liquefaction and become surrounded by a wall of fibrous tissue. Ivy and Curtis [8] described traumatic cysts of the jaws. They compared them to those cysts found in long bones which are not lined with epithelium and which are believed to result from the metamorphosis of hematomas following trauma. This type of cyst is mentioned because 1 case in this series was of a bone cyst in the canine fossa following trauma. A study of the literature failed to discover a report of a similar case occurring in the maxilla.

CASE 6.—F. A., a youth aged 15, had as the chief complaint an enlargement of the right side of his face, with impaired movements of the cheek, and a somewhat loose and tender central incisor tooth, with the occasional escape of a bad-tasting fluid in his mouth (fig. 4). This trouble had developed gradually over a period of three months, after he had been hit in the right cheek with a machine-driven rubber belt. The accident had caused unconsciousness for about two hours. Examination revealed a bony thickening over the canine fossa and along the side of the nose, encroaching on the pyriform aperture, with partial occlusion of the

7. Boyd, W.: Surgical Pathology: An Introduction to Medicine, ed. 3, Philadelphia, W. B. Saunders Company, 1934, p. 176.

8. Ivy, R. H., and Curtis, L.: Hemorrhagic or Traumatic Cysts of the Mandible, Surg., Gynec. & Obst. **65**:640-643 (Nov.) 1937.

right naris. There was impaired mobility of the soft tissues, which were made adherent by a fibrous scar. Sensation was decreased in the skin. Roentgenologic examination revealed changes which suggested that an old fracture had healed with osseous proliferation and trabeculation, resembling a bone tumor or cyst. At operation the area was exposed by a Caldwell-Luc incision under the upper lip. A thin, irregular layer of bone, attached to the soft tissues and separated from the natural surface of the canine fossa by an interval of space, was encountered. This space apparently had contained fluid, which had escaped unnoticed during the

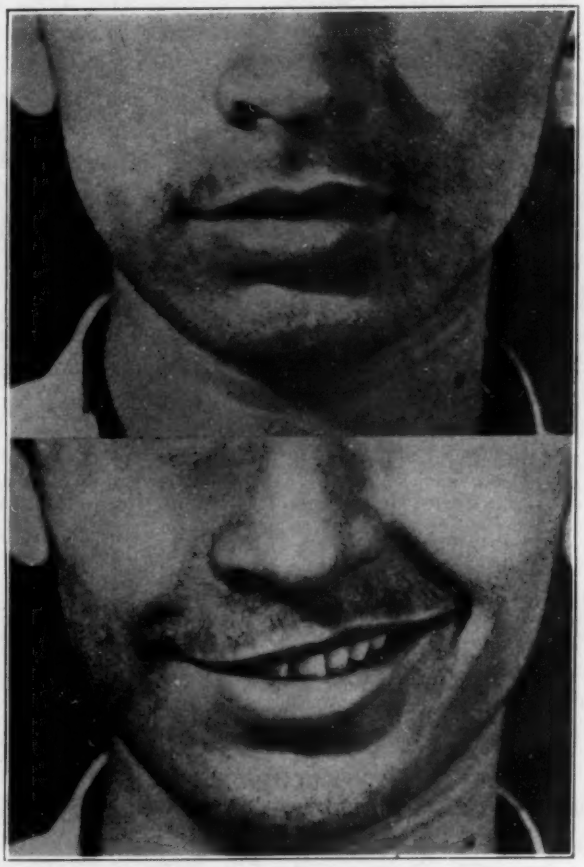

Fig. 4.—A traumatic bone cyst in the right canine fossa.

exposure. This outer plate covered most of the canine fossa and joined a hard, bony callus, which encroached on the pyriform edge. The maxillary sinus was opened and found to appear normal, and so the lining was not removed. Microscopic sections of bony tissue showed no evidence of neoplasm. No epithelial lining was present. Healing was uneventful. Later a submucous resection was done to provide better breathing on the right. No further surgical correction was required for the partial stenosis of the pyriform opening on the right.

Comment on Case 6.—The development of this cyst can be explained in the following way: At the time of injury a fracture probably occurred and was followed by a hematoma, which separated the periosteum of the canine fossa from its bone. While the hematoma was slowly absorbing, the osteogenic layer of the periosteum produced another layer of bone, which remained distinct from the original bone surface. Whether or not the outer layer of bone was covered with normal periosteum was not determined microscopically, but its gross appearance led to the conclusion that it was.

CYSTS OF DENTAL ORIGIN

Embryologically, a tooth arises from both ectoderm and mesoderm. In the second month of fetal life the gingival epithelium invaginates to form the dental ridge. Epithelial buds push farther into the mesoderm and form the enamel organ. Later, a concentration of mesoderm, composing the dental papilla, invaginates this epithelial mass. These elements, with the connective tissue surrounding them, comprise the dental follicle.

Groups of epithelial cells, remnants of the dental ridge, the enamel organ and the sheath of Hertwig, were found and described by Malasséz [9] in 1885 and are spoken of as the epithelial debris. It is generally considered that this debris is related to the origin of certain cysts and tumors of the jaws.

Much study has been devoted to the problem of odontomas, a term used to include tumors and cysts originating from dental embryonic remnants. Many reports of cases and excellent articles wth elaborate bibliographies are found in the literature, from works appearing about the middle of the last century up to and includng recent publications and textbooks.[10] The present discussion will include only two types of the odontomas: the follicular cyst and the radicular cyst. Adamantinoma is a multilocular cystic odontoma but will not be discussed in this paper.

In many respects these two cysts are similar. The differentiation is usually made clinically and by surgical findings. First will be emphasized the points in which they differ: The follicular cyst usually arises from an unerupted or undeveloped tooth of the second dentition or from a tooth which may be normal and fully developed but impacted or misplaced anywhere in the superior maxilla. This tooth may be abnormally developed or deformed or entirely absent. There may be

9. Malasséz, L., cited by Padgett.[10]

10. Padgett, E. C.: Surgical Diseases of the Mouth and Jaws, Philadelphia, W. B. Saunders Company, 1938, pp. 670-688.

supernumerary or multiple teeth. Chung and Boots[11] reported a dentigerous cyst containing 33 small teeth. Hildebrand[12] removed 150 rudimentary teeth from one cyst. The radicular cyst always arises from an erupted tooth which has become devitalized and infected, with the formation of a granuloma at the root. The tooth may have been previously removed, long before the development of the cyst.

In the follicular cyst the crown of the affected tooth is directed into the cyst, while its root is embedded in the surrounding bone. There is often a thin shell of bone either partially or completely surrounding the cyst. In the radicular cyst the reverse is true. The root is directed toward the cyst, and the granuloma at the root takes part in the formation of the cyst. The crown may be found in its normally erupted position, and the root may be found to be loose in its socket.

The follicular cyst is a rare cyst, found more frequently in the lower jaw than in the upper and most commonly associated with the cuspid and molar teeth. The radicular cyst is relatively common and is more frequent in the upper jaw than in the lower. It arises most often from the incisor and bicuspid teeth. Cysts in the superior maxilla are twice as frequent as those in the mandible.

The following similarities exist between the two types: They both arise from embryonic rests, and both have been reported in persons of widely varying ages. Either may exist for many months or years without causing conspicuous symptoms. Either type may be multiple. Either cyst may become infected and discharge into the mouth at intervals or may form a fistula. Both types grow slowly and may produce considerable deformity. They frequently bulge into the maxillary sinus or fill it completely. The pressure may cause absorption and thinnng of any of the bony walls of the cyst, so that it becomes flexible and crackles, as does the wall of a celluloid ball on pressure. Complete absorption of the bony walls may occur, leaving a fluctuating tumor.

Histologically these cysts are so similar that they cannot be distinguished from each other. The lining is of stratified squamous epithelium of varying thickness. The wall is of connective tissue, which may be either very cellular or fibrous, it may be loose or packed, and it is usually infiltrated with inflammatory cells. The surface of the lining may show ulceration and granulations. The surrounding bone

11. Chung, P., and Boots, J. L.: A Dentigerous Cyst Containing Thirty-Three Small Teeth, J. Am. Dent. A. **23**:225-226 (Feb.) 1936.

12. Hildebrand, O.: Weiterer Beitrag zur Lehre von den durch abnorme Zahnentwicklung bedingten Kiefertumoren, Deutsche Ztschr. f. Chir. **35**:604-609, 1893; cited by Harris and Weidlein.[13]

13. Harris, H. L., and Weidlein, I. F.: Dentigerous Cysts of the Antrum of Highmore with Unusual Characteristics, Arch. Otolaryng. **12**:311-319 (Sept.) 1930.

will show mixed changes, both regressive and proliferative. The adjacent teeth may be devitalized from pressure on their roots.

The contents of these cysts are usually viscid and sticky but may be thick and cheesy or thin and watery. The color is usually amber but may be dark or brownish. Cholesterol crystals may produce a shimmer in the light. Bacteriologically, the contents are usually sterile, but they may have nonvirulent bacteria or may be infected with pathogens. Micro-organisms are especially likely to be present if the cyst has been incised or ruptured.

Late in their progress these cysts may cause neuralgia, nasal obstruction or other nasal symptoms. The cyst may bulge into the nose, the palate, the orbit or the canine fossa, causing external deformity.

The treatment is the same for the two types. Complete removal of the sac and the affected tooth is the only accepted procedure. The results are nearly always good and usually leave little, if any, residual deformity.

In this series there were 6 cases of follicular cyst and 9 of radicular cyst. Of the patients with follicular cysts, 1 was a woman aged 31, and the others were all boys 18 years old or under, the youngest being 9 years old. In all but 1 case the cyst was on the right. A third molar was involved in 2 cases, a bicuspid in 2 cases, a cuspid in 3 cases and a lateral incisor in 1 case. In 1 case no tooth could be found related to the cyst. In 2 cases two teeth were found within the cyst. In 2 cases there was a definite history of trauma several years previously. The duration of symptoms varied from three months up to four or five years. In all cases there was some visible external deformity, due to bulging of the sinus walls. In the fluid contents of the cyst obtained in 1 case was an abundant amount of cholesterol crystals, which glittered when held up to daylight.

In 6 of the 9 cases of radicular cyst, the cyst invaded the antrum, completely filling it and causing its walls to bulge. In 3 cases the cyst had invaded the bone of the hard palate without invading the sinus, causing protrusion of the upper lip, bulging into the floor of the nose or into the mouth. There were 5 male and 4 female patients, the ages ranging from 16 to 66. All but 2 patients were over 30 years of age. In 5 cases the right side was involved and in 4, the left. The duration of symptoms was usually about six months, but in 1 case definite symptoms occurred intermittently for almost forty years. The area of the incisors seemed to be the commonest location for the beginning of these cysts, but in 1 case as many as four teeth were involved, at least in the later stages.

All the radicular cysts were related to roots of teeth which had erupted or to granulomas which had remained in the region of the

roots after extraction of the teeth. Three patients were edentulous. In 2 cases there was a definite history of trauma. In 1 case there was a history of an "abscess" of three upper teeth. In 1 case four teeth were removed with the cyst at the time of operation. These teeth had been devitalized by the granulomas at their roots, in addition to the presure from expansion of the cyst. They had been displaced from their normal positions and were loose in their sockets.

The following cases of cysts of dental origin are presented:

CASE 7.—S. R., a youth aged 18, had a follicular cyst. He had first noticed a swelling of the right cheek seven or eight years previously. This swelling had become prominent the last few months and had been lanced twice, with only temporary improvement. Examination revealed bulging of the cheek, extreme bulging of the labial and buccal plate of the alveolar process and displacement of the lateral nasal wall against the septum. Roentgenograms showed a cuspid

Fig. 5.—A follicular cyst of the right antrum, containing a cuspid tooth.

tooth displaced high in the maxilla, with diffuse clouding of the maxillary sinus (fig. 5). Surgical removal was accomplished through an intraoral incision above the gingival margin. All walls of the antrum were very thin, with complete absorption of bone in some areas. The cyst completely filled the sinus and had increased in size by pushing its walls outward in all directions. A portion of the bony floor of the orbit came away with the tooth, whose root extended up into the orbit and whose crown was embedded in the cyst. The contents of the cyst were a straw-colored, thick, serous fluid. Postoperative recovery was without incident, and when the patient was last seen, three months later, the deformity was distinctly reduced.

CASE 8.—B. S., a woman aged 31, had a follicular cyst. The patient was admitted to the hospital with acute pain and swelling of one week's duration, over the right maxillary sinus. This condition had been initiated by a head cold and had become so severe that when admitted the patient was almost in hysteria from pain and had been vomiting. About one year before admission, routine dental roentgenograms had revealed absence of the upper right third molar. The

patient had had episodes of mild attacks of pain and postnasal discharge for about one year following an acute attack of maxillary sinusitis. Swelling had never been noticed until the week before admission. Six months before, the patient had had a nervous breakdown, had lost several pounds in weight and had been in bed for two months. Four days before her admission, an unsuccessful attempt had been made to irrigate the antrum. This procedure had aggravated the symptoms. On admission the patient appeared very ill and nervous. The temperature was 100 F. The pulse rate was 90, and the blood pressure was 140 systolic and 100 diastolic. The white blood cell count was 11,400, with 81 per cent polymorphonuclear cells. There were exquisite tenderness and swelling over the right cheek, extending down over the mandible and associated with redness of the conjunctiva on the same side. There was pronounced trismus, with about one-third normal movement. The right nasal passage was crowded by a deviated septum and swollen turbinated bodies. There were pus in the middle meatus and a purulent postnasal discharge. Transillumination showed that the right antrum was dark. Dental examination revealed excellent teeth except for the absence of the upper right third molar. Roentgenologic examination showed cloudiness of the right maxillary sinus, which contained a tooth, apparently the missing third molar, lying buccolingually, ⅛ inch (3 mm.) above the floor of the sinus. Because of the patient's nervous state and the apparent active infection, conservative measures were instituted immediately. The next day an attempt was made to establish drainage by an opening made in the inferior meatus with a Thornwald trephine. Manipulation of a curved cannula passed through this opening gave the sensation that its end was embedded in a semisolid material. No irrigation fluid would pass through. A small amount of bloody-appearing, gelatinous material was on the cannula when it was withdrawn. After three more days of conservative treatment, the symptoms were still evident but had somewhat subsided. With the use of local anesthesia, a radical operation on the maxillary sinus was done through an incision in the gingivolabial fold. The sinus was observed to be filled with a brownish red mixture of cheesy and gelatinous material. A cyst wall, consisting of a thickened, inflamed, fibrous membrane, was found practically filling the sinus and containing a tooth lying on its floor. Several small pieces of bone, about the thickness of eggshell, were attached to the mass. The mucosa of the antrum showed chronic inflammatory hyperplasia, and so it also was removed. A large window in the inferior meatus was made and the wound allowed to close with no packing or sutures. Microscopic study showed inflammatory changes in the sinus mucosa. The stroma of the cyst wall showed varying density, inflammatory reaction, some multinucleated giant cells, probably representing a reaction to a foreign body, and hyaline changes (fig. 6). The lining was composed of a layer of modified squamous epithelium and showed degeneration in some areas. Culture of the contents of the cyst produced a gram-negative bacillus.

The postoperative recovery was rapid, and the patient, feeling well, left the hospital on the third day. Ambulatory treatment was continued for about four weeks. The patient was seen six months later, at which time no further symptoms had developed, and no deformity was present.

Case 9.—C. P., a boy aged 12, had a follicular cyst (fig. 7). There had been a painless swelling over the left cheek for two months. An upper tooth had been knocked out in this region, in a bicycle accident, when the patient had been 4 years old. Examination revealed a distinct deformity, with bulging of the cheek. Palpation gave a sensation of flexibility, like that of a celluloid ball. A semitransparent, amber fluid, containing visible glittering crystals, was aspirated by needle

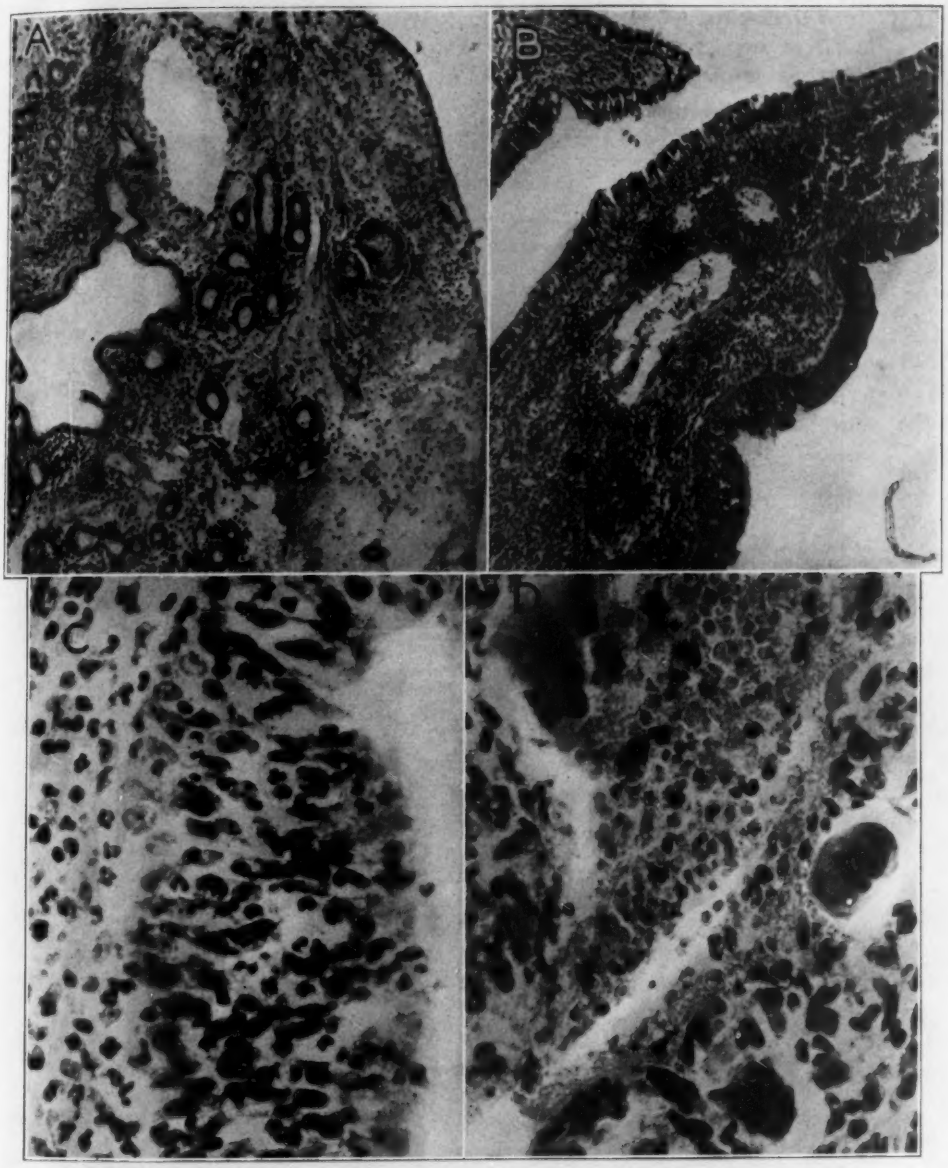

Fig. 6.—*A*, sinus mucosa, with eroded epithelium, distended mucous glands and clear spaces, probably filled with cholesterol; *B*, sinus mucosa, exhibiting extreme cellular infiltration; *C*, migration of polymorphonuclear leukocytes through the epithelium, and *D*, giant cells, indicating reaction due to a foreign body.

inserted under the lip. Examination of the crystals under a polarizing microscope revealed them to be cholesterol. Culture of the fluid produced a growth of streptococci. Roentgenograms showed a cloudy antrum, with what appeared to be a misplaced cuspid tooth near the pyriform crest. A radical operation on the antrum was performed through the gingivolabial fold. The entire cyst, containing a tooth in

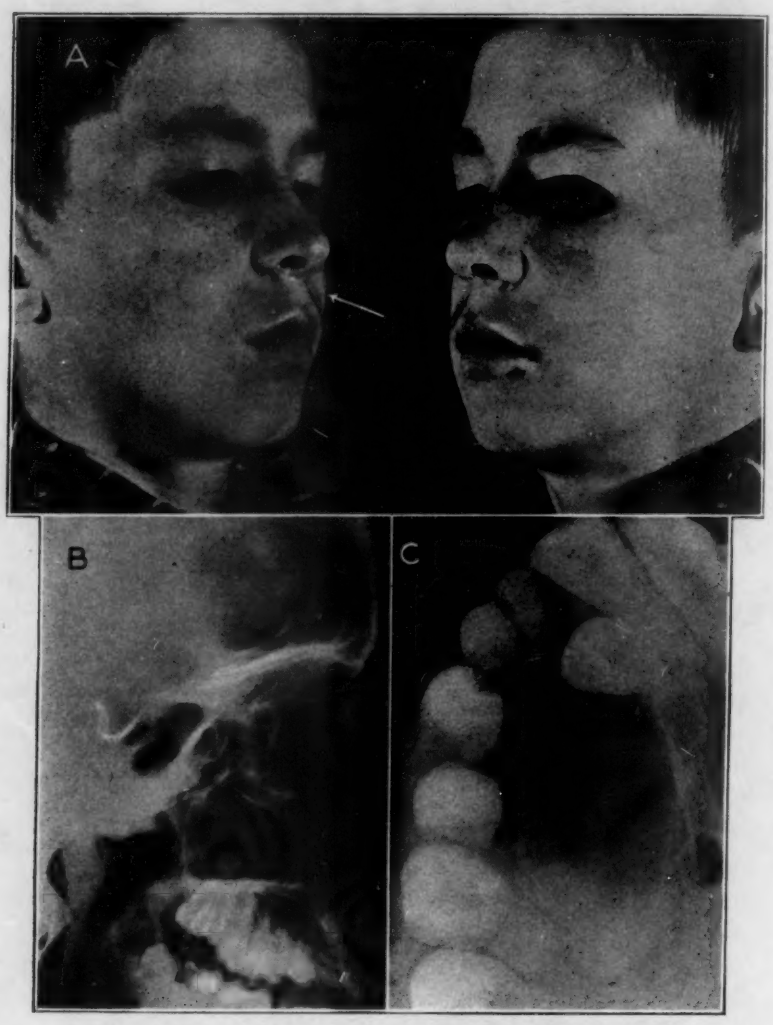

Fig. 7.—*A*, follicular cyst of the left antrum; *B*, roentgenograms of the same, and *C*, an occlusal film showing absorption of the bone of the palate, and alveolar process and the displacement of teeth.

its wall, was dissected free from the sinus lining and removed intact except for the fluid contents, which escaped. The involved tooth was a cuspid tooth and had its crown contained within the cyst. The root was impacted anteriorly in the nasoantral wall, near the floor of the sinus. Microscopic sections of the cyst showed

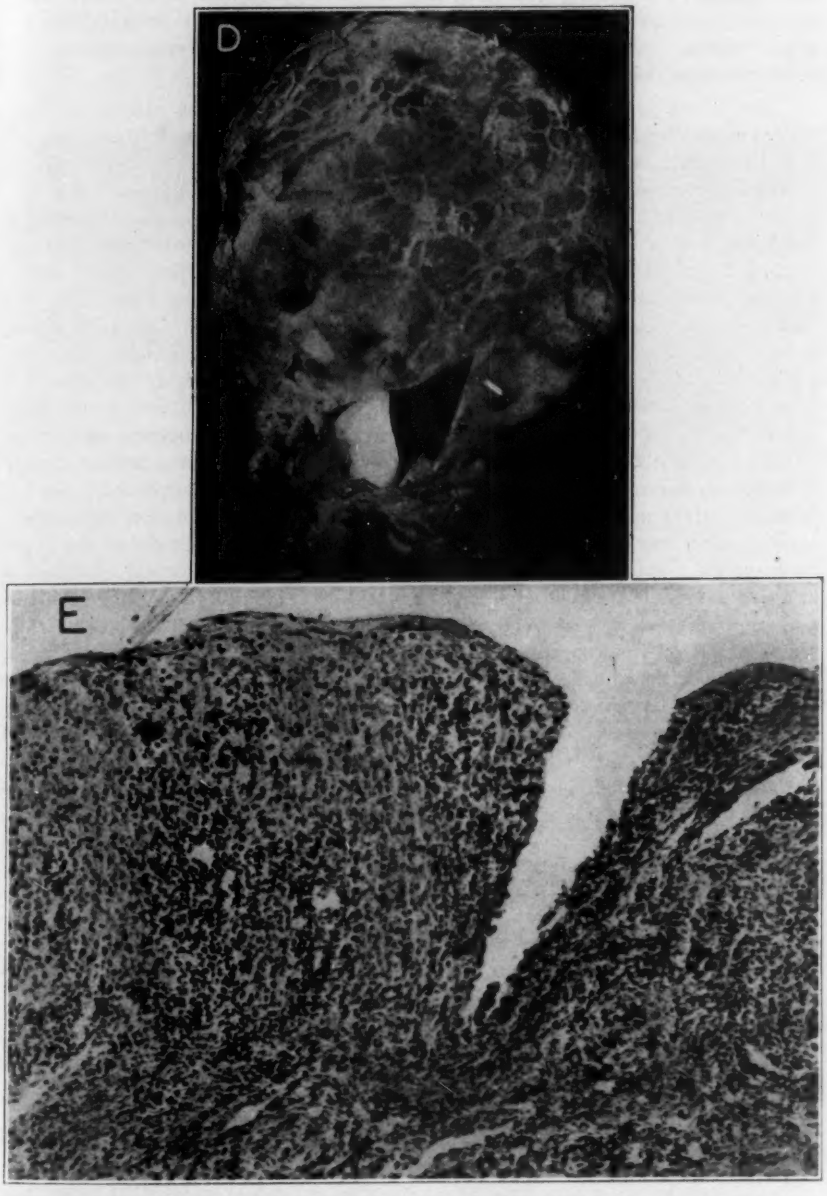

Fig. 7 (continued).—*D*, complete cyst with cuspid tooth, and *E*, wall of the cyst, of stratified squamous epithelium with a pronounced inflammatory reaction.

stratified squamous epithelium on a fibrous stroma, with considerable inflammatory reaction. Postoperatively there were moderate swelling and a purulent discharge, which produced a growth of streptococci on culture mediums. This cyst cleared promptly after a few irrigations, but there remained a small oroantral fistula, which required secondary closure a few months later. After several weeks, the facial deformity was no longer noticeable.

CASE 10.—R. J., a boy aged 15, had a follicular cyst. The patient had first noticed a swelling on the right cheek two years before his admission to the hospital. It had gradually increased in size and had become very painful and associated with nausea and vomiting. The cyst had finally ruptured into his mouth releasing a thin, yellow, foul-smelling discharge. The patient had been treated several times by a physician, who repeatedly had aspirated fluid and injected a medicament into the space. About two weeks before the patient's visit to this clinic, the swelling was so great that the entire side of his face was distorted. Something had ruptured into the mouth and released about 3 ounces (90 cc.) of fluid, giving great relief. The patient had been referred to the White Memorial Clinic, with a diagnosis of suspected sarcoma. Examination revealed a firm, but somewhat compressible, swelling over the right cheek. The anterior portion of the hard palate, the floor of the nose and the nasoantral wall were all bulging away from the cyst. Slightly cloudy, amber fluid was withdrawn through a needle inserted into the inferior meatus. Roentgenologic examination (fig. 8) revealed a density filling the right antrum. The third molar tooth was unerupted and incompletely developed but was not definitely connected with the cyst. The roots of the upper teeth on the right side were somewhat displaced outward. Physical examination and laboratory tests otherwise revealed nothing significant. A Caldwell-Luc operation revealed a cyst which filled the antrum and was shelled out with little difficulty. No direct connection with any tooth or root of a tooth could be found. The wall was thick and dense in some areas, with an average thickness of about 1.5 mm. The lining presented hemorrhagic areas and numerous small, yellowish tubercular elevations. Microscopic sections showed a chronically inflamed fibrous stroma, bearing a layer of stratified squamous epithelium. The continuity of epithelium was broken frequently by elevations or nodules of budding granulation tissue (fig. 8*C*). Some of these nodules contained phagocytic cells filled with yellowish brown pigment. The patient made an uneventful recovery and was last seen eight months after the operation. At that time there was practically no residual deformity or recurrence of symptoms.

Comment on Case 10.—This case was tabulated as one of a follicular cyst, although no connection to an unerupted tooth could be found. Since there was no gross evidence of a granuloma at the roots of any of the teeth, or any roentgenologic evidence of dental infection, it was not deemed that this cyst conformed to the usual radicular cyst. It is possible that it may have originated from epithelial debris which was in proximity to the enamel organs but which became detached from them in the process of growth.

CASE 11.—H. S., a man aged 53, had a radicular cyst. At the age of 12 years he had broken the left upper incisor tooth. The roots had been removed at the age of 16 because of infection. Four years later the patient had had further trouble, and his jaw had been curetted by a dentist. About fifteen years before admission his jaw had swelled, and at the same time he had had an attack of acute generalized arthritis. Swelling had occurred intermittently since. The patient also had had

episodes of rheumatism, which had become severe during the previous year. His trouble had always been aggravated during the winter, when he had had many colds and sinus infections. Three weeks before admission, the swelling had been extreme, almost closing his left eye, until it finally ruptured into his mouth near the left canine tooth, discharging foul pus. This was practically the only time he had had any pain. Examination revealed a large crepitant mass over the entire

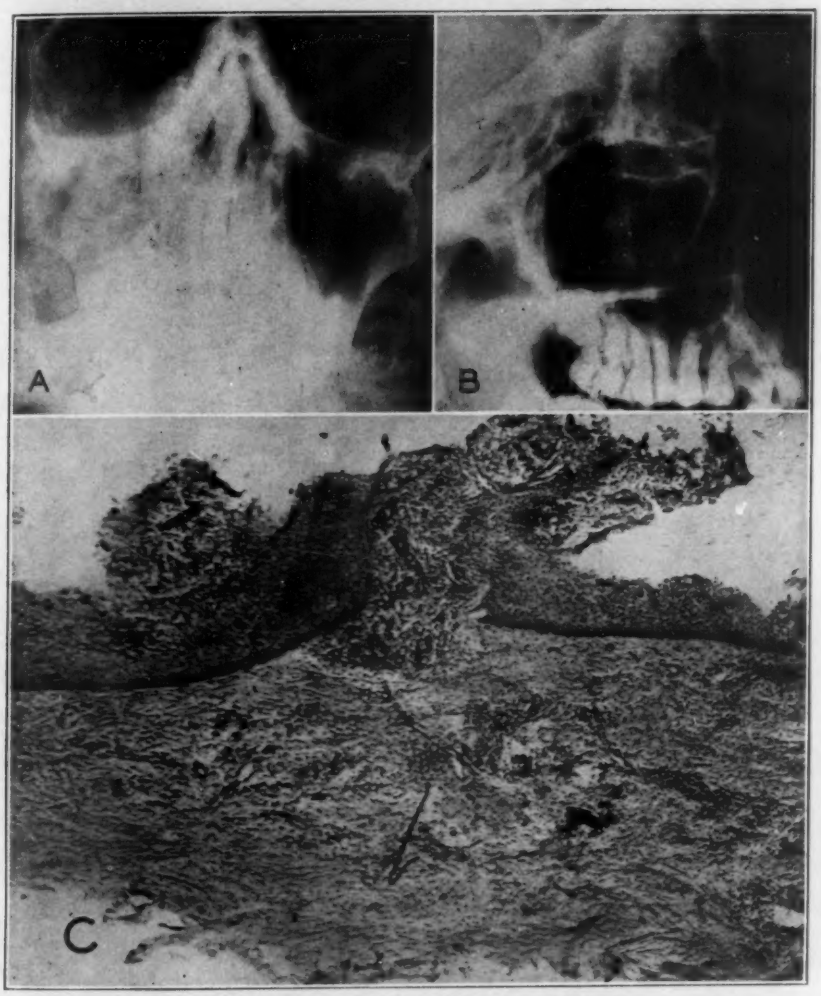

Fig. 8.—*A* and *B*, a follicular cyst of the right maxillary sinus, not connected with a tooth, and *C*, stratified squamous epithelium of the wall of the cyst, with buds of infected granulation tissue.

left side of the upper jaw and the left cheek (fig. 9 *A*). It also involved part of the hard palate. Roentgenograms showed the left antrum to be dark. Bite films (fig. 9 *B*) showed a large rarefied area, involving the alveolar process and a large portion of the hard palate, and also revealed the absence of the two left incisors.

The hazy borders of this rarefied area were suggestive to the roentgenologist of pathologic changes due to infection or a neoplasm, rather than a cyst. A Caldwell-Luc operation was performed and the entire cyst dissected out in one mass (fig. 9 *C*). Three teeth, including the cuspid tooth, whose roots were involved, were also removed. Cultures taken from the cyst produced a growth containing streptococci, staphylococci and Neisseria catarrhalis. The microscopic sections of the cyst presented a wall with a lining of densely packed squamous epithelium and severe chronic and subacute inflammation, with ulcerations. The formation of bone was

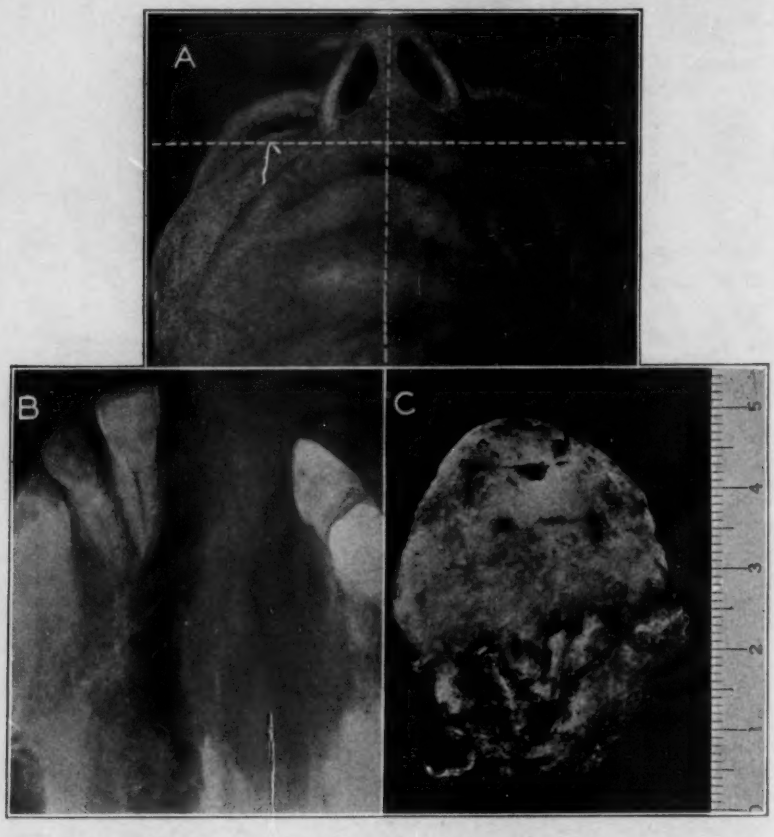

Fig. 9.—*A*, *B*, and *C*, a follicular cyst involving the left maxillary sinus.

taking place in the cyst wall (fig. 9 *D* and *C*). This bone showed osteolysis on the inner surface and osteoblastic activity on the outer aspect. The patient made a good recovery.

Case 12.—E. H., a man aged 20, had a radicular cyst (fig. 10). The patient's complaint was a swelling of the left cheek, which swelling had begun as a small lump six months before. It had been aspirated three weeks previous to his admission but had filled up again after one or two days. There had been a sensation of pressure over the left eye, but no pain. A partial nasal obstruction was present on that side. Examination showed a distinct bulging of the left cheek

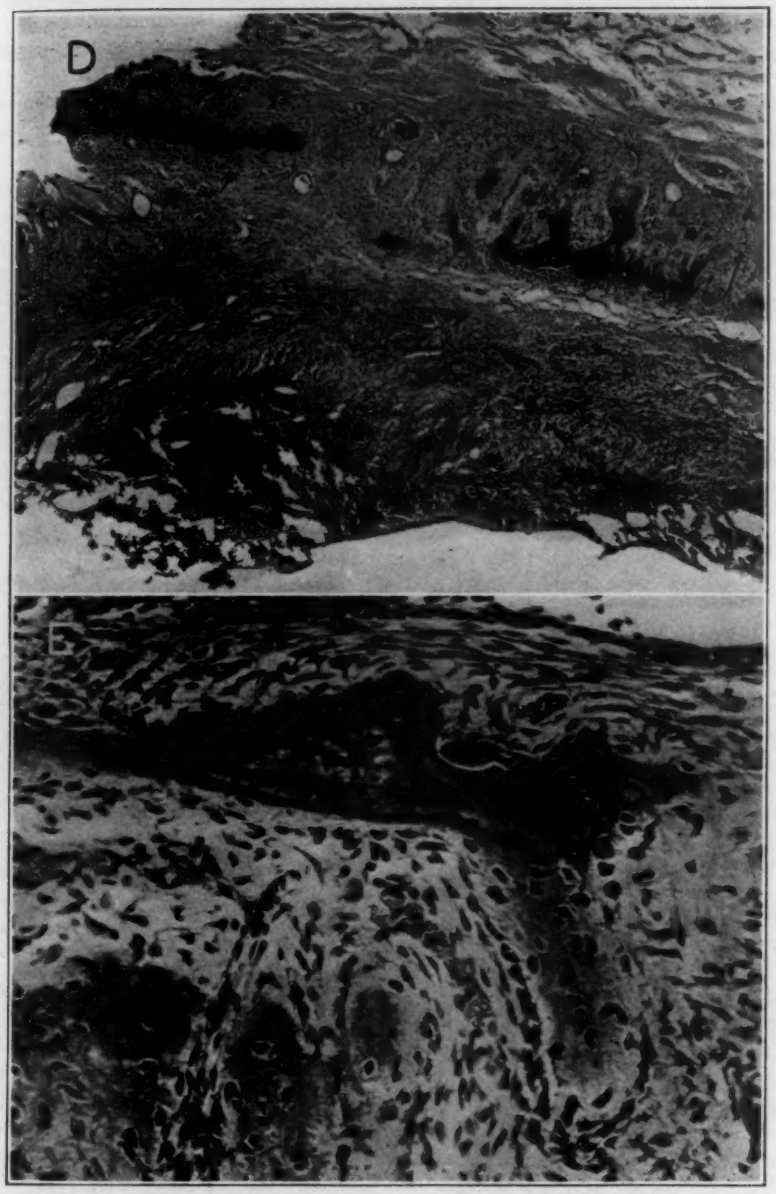

Fig. 9 (continued).—*D*, formation of bone in the wall of the cyst, and *E*, photomicrograph with osteoclasts and osteoblasts both clearly in evidence.

by a compressible mass. The nasoantral wall was also displaced toward the septum. The crowns of the upper teeth on the left side had been rotated lingually, while the roots had been displaced externally. Roentgenologic examination showed a cloudy left antrum, with thinning of its walls, and displacement of the roots of four teeth. The occlusal film showed absorption of the hard palate and the rotation of the teeth. A Caldwell-Luc operation was performed with the use of local anesthesia. The outer bony wall of the antrum, the lateral cortical plate of the alveolar process in the region of the bicuspids, a portion of the orbital floor and

Fig. 10.—A radicular cyst of the left maxillary sinus.

the bony nasoantral wall were absent, as a result of pressure atrophy. The infra-orbital nerve and some alveolar branches were lying on the wall of the cyst and were preserved as carefully as possible. The lateral incisor, the cuspid and two bicuspid teeth were removed because of extensive granulomas at the apexes and a lack of bony fixation. The cyst wall was entirely dissected out, but only a portion of the sinus lining was removed. A large nasoantral window was made. Recovery was uneventful, and deformity was minimal.

CASE 13.—C. D., a man aged 32, had a radicular cyst in the hard palate. The patient complained that he had had a nasal and postnasal discharge and chronic sore throat for five or six months. The principal pathologic change in the nose was a deviated septum. A submucous resection was performed. While the nasal crest was being removed, a pocket in the floor of the nose was encountered. This was found to extend deep into the bony palate and forward and backward on both sides of the midline. It was filled with a caseous, foul-smelling material. At this time an opening for drainage into the floor of the nose was made on the right side, and the septum was allowed to heal. About three weeks later a second operation was performed for the removal of the cyst. Exposure was gained through the hard palate after reflection of the mucoperiosteum of the anterior third of the palate, beginning immediately behind the incisor teeth. A gouge and rongeur were used to open through the bony palate and expose the cyst. The entire lining of the cyst was dissected out. The cyst was found to extend laterally the entire

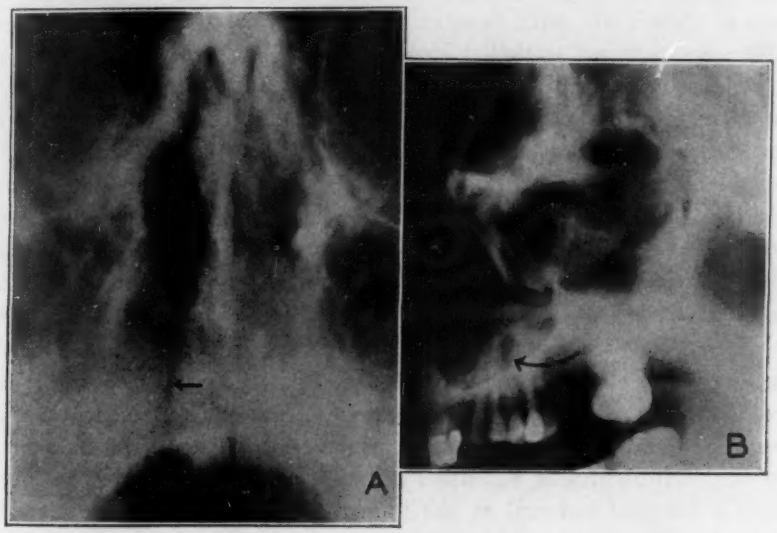

Fig. 11.—*A*, a radicular cyst of the hard palate, and *B*, a cyst of the palate, showing absorption of the alveolar process.

width of the nasal floor on both sides. The bony floor of the nose was absent. The membranous nasal floor was incised and allowed to reflect into the cystic cavity. The right cuspid tooth, with a granuloma on its root, was found to be related to this cyst, and the tooth was removed. The palatal flap was replaced, and the wound healed without incident. The floor of the nose, after operation, presented a deep cavity on each side with a connection through and through below the septum, the retraction of which, upward away from the floor, gave the effect of a low septal perforation. The patient's last visit was two months after the second operation. Healing had been quite satisfactory, but the deep space in the floor of the nose tended to act as a reservoir for the collection of secretions, which would drain out when the patient leaned far forward. Further observations were prevented by my entrance into military service. Microscopic sections of the cyst wall proved it to consist of a lining of squamous epithelium on a fibrous stroma with chronic inflammatory changes.

Comment on Case 13.—The location and gross appearance of this cyst would lead one to classify it as a median anterior maxillary cyst, but its definite connection with the granuloma at the root of the tooth leads one to classify it as a radicular cyst of the palate. Now that I have been released from military service, I shall attempt to contact the patient for further study of the problem of the cistern on the nasal floor and the subseptal perforation.

CYSTS OF NONDENTAL DEVELOPMENTAL ORIGIN

Median anterior maxillary cysts were observed by Meyer [14] in 1908, and the cyst was described by him in 1914 as a supernumerary paranasal sinus directly above the superior incisors. Schroff [15] described such a lesion as a cyst of the nasopalatine duct. Havens [16] reviewed cases of these cysts, with those of other benign cysts of the jaw. These cysts develop from epithelial elements remaining after the closure of the wide communication between the nasal and the oral cavity which exists in early fetal life. In the normal adult this closure is represented by the nasopalatine canal. Cysts developing here will be located anteriorly in the midline of the upper jaw and just above the roots of the central incisors. The lining of the cyst may be derived from either nasal or oral epithelium or may be transitional in type. This cyst rarely causes symptoms and may be discovered only on routine roentgenologic examination. The treatment is surgical removal.

Facial cleft cysts [15] arise from epithelial remnants found along the line of fusion where the medial and lateral nasal processes join the maxillary process. Cleft palate and harelip represent extreme degrees of failure of fusion here, while cysts located just below the ala nasi represent less extensive failures in development. The treatment is surgical removal of the lining through an incision under the upper lip. Rosenberger [17] reported 2 cases of cysts: 1 of the facial cleft and 1 of the nasopalatine canal.

Case 14.—M. K., a woman aged 54, had a median anterior maxillary cyst. The patient stated that for the last nine months she had had an abscess inside her left nostril, which had frequently drained yellow pus. The lesion had at first been manifested by a small lump inside the ala. It had been lanced twice by a

14. Meyer, A. W.: Median Anterior Maxillary Cysts, J. Am. Dent. A. **18**: 1851-1877 (Oct.) 1931.

15. Schroff, J.: Unusual Cysts of the Maxilla: Cyst of the Naso-Palatine Duct; Cyst of Facial Cleft Area (Fissural Cysts), Laryngoscope **39**:173-184 (March) 1929.

16. Havens, F. Z.: Benign Cysts and Adamantinomas of the Jaws, Arch Otolaryng. **30**:762-774 (Nov.) 1939.

17. Rosenberger, H. C.: Fissural Cysts, Arch. Otolaryng. **40**:288-290 (Oct.) 1944.

physician and had drained spontaneously several times. Recently it had become somewhat painful. Examination revealed a rounded swelling in the floor of the left side of the nose, adjacent to the septum and opposite the anterior tip of the inferior turbinate body. This mass was fluctuant. Aspiration with a needle obtained about 1.5 cc. of pus. Culture produced a growth of Staphylococcus aureus. Roentgenologic examination of the palate showed an oval area of decreased density, of about 8 by 4 mm., surrounded by a thin, compact bony wall, lying in the midline (fig. 12 *A*). Other findings on physical examination were unrelated to the lesion, and laboratory examinations disclosed nothing abnormal. The patient refused to undergo operation and did not return for further observation, although the diagnosis seemed to be clearcut and surgical extirpation was indicated.

CASE 15.—Another patient with a median anterior maxillary cyst was observed and operated on by me in association with the oral surgeon in July 1946 while I was on duty in a United States Naval Hospital. The patient, a man aged approximately 25, had complained of aching in the upper incisor teeth. Roentgeno-

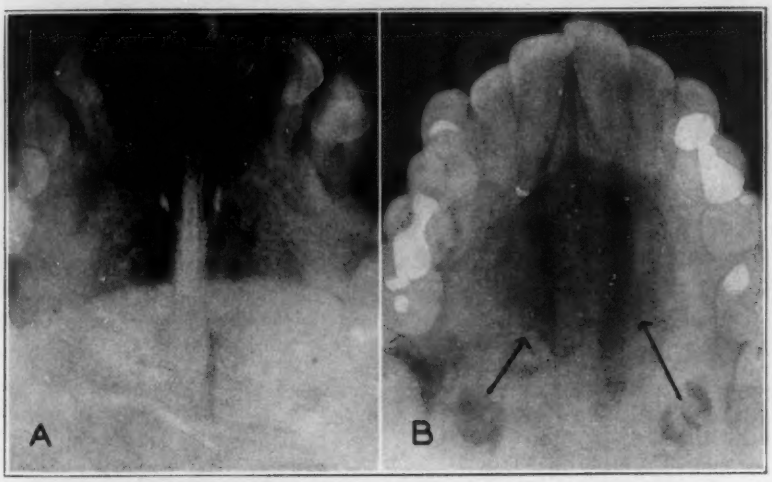

Fig. 12.—Roentgenograms of 2 cases of median cyst of the palate.

grams showed an oval area of decreased density, with distinct, compact margins, lying in the center of the anterior third of the hard palate (fig. 12 *B*). Surgical excision was accomplished by a curved incision in the mucous membrane of the palate several millimeters posterior to the gingival margin. The bony wall was removed with a gouge and a rongeur. The cyst wall was completely dissected out, leaving a cavity of about 1.5 by 3 by 5 cm. The wall of the cyst was separated from the floor of the nose by a very thin bone, and in one area by only mucous membrane, but no connection with the nasal cavity could be detected. The cavity was sprinkled with sulfanilamide crystals and the incision closed without drainage. Healing took place without infection or fistula. Because of a change in duty, it was impossible for me to obtain a report on the microscopic examination.

DIAGNOSIS

Diagnostic procedures for cysts of the superior maxilla should include a full history of the complaint; a history and examination of the

ears, nose and throat, a dental history and examination; careful inspection and palpation of the canine fossa, alveolar processes and hard palate; transillumination and roentgenologic examination of the sinuses; if possible, after instillation of radiopaque oil, second dental roentgenograms, including bite, or occlusal, films, and a diagnostic puncture of the antrum. The climax of all diagnosis is exploration of the antrum, or cyst, removal of its contents and microscopic examination by the pathologist.

The principal conditions to be differentiated are polypi, mucocele, empyema, osteomyelitis, sarcoma, carcinoma and other odontomas.

The obtaining of bloody fluid by puncture of the antrum should suggest the presence of a malignant growth. The final diagnosis may not be established until surgical exploration is performed.

SUMMARY

Thirty cases of cysts of the superior maxilla are reviewed, in 24 of which the maxillary sinus was the site. Fifteen cases are briefly presented in this paper. Fifteen cysts of the series were of dental origin; 6 were follicular or dentigerous, and 9 were radicular. Five were nonsecreting cysts of the sinus mucosa, and 6 were secreting or retention cysts. One was a traumatic bone cyst; this type of cyst of the superior maxilla was not found to have previously been reported. Two were of median anterior maxillary cysts and 1 was not definitely classified but is tentatively presented with the nonsecreting cysts. A classification is proposed. The pathogenesis, pathology and clinical features are briefly discussed and illustrated by photographs and photomicrographs.

453 South Soto Street (33).

GLYCERITE OF HYDROGEN PEROXIDE WITH UREA

III. Comparison by In Vitro Methods of Its Bacteriotoxic Action with That of Three Proprietary Aural Preparations

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AND
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BOSTON

FOLLOWING the first reports [1] of the efficacy of glycerite of hydrogen peroxide in treatment of infections of the middle ear, subsequent studies showed the solution to be bacteriotoxic for Mycobacterium tuberculosis hominis [2] and for all oral fusiform and spirochetal organisms [3] in both in vivo and in vitro tests. For this paper, the solution was compared with three proprietary aural preparations. The laboratory methods used simulated as closely as possible the clinical conditions for which such solutions are prescribed.

The solutions of glycerite of hydrogen peroxide, which were also compared with each other, had the following formulas:

1. Hydrogen peroxide, 1.46 per cent, as derived from urea peroxide, 4 per cent, with oxine (8-hydroxyquinoline, 8-quinolinol), 0.1 per cent, in glycerin.

2. Hydrogen peroxide, 1.5 per cent, as derived from hydrogen peroxide, 92 per cent, with or without oxine, 0.1 per cent, in glycerin.

The control solutions consisted of glycerin, glycerin with oxine, 0.1 per cent, and glycerin saturated with urea.

The three proprietary preparations were as follows:

1. Auralgan® (Doho Chemical Corporation), labeled as containing antipyrine, 0.87 Gm.; ethyl aminobenzoate (benzocaine), 0.23 Gm., and glycerin, 0.63 Gm.

2. Otosmosan® (Doho Chemical Corporation), labeled as containing urea, 2.4 Gm.; sulfathiazole, 2.02 Gm.; ethyl aminobenzoate, 0.20 Gm., and glycerin, 20.0 Gm.

3. Otomide® (White Laboratories), labeled as containing sulfanilamide, 5 per cent; urea 10 per cent, and chlorobutanol, 3 per cent, in glycerin.

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1. Brown, E. A.; Aagesen, W., Jr., and Weiss, L. R.: Glycerite of Hydrogen Peroxide: Its Use in Various Inflammatory Aural Conditions, Eye, Ear, Nose & Throat Monthly **26**:27-31, 1947. Brown, E. A., and Kelemen, G.: The Use of Glycerite of Hydrogen Peroxide in Inflammatory Aural Conditions: Clinical Report, Laryngoscope **56**:556-560, 1946. Brown, E. A., and Owen, W. E.: The Treatment of Chronic Purulent Otitis Media with Glycerite of Hydrogen Peroxide, Arch. Otolaryng. **43**:605-612 (June) 1946.

2. Brown, E. A., and Slanetz, L. W.: Antiseptic Action of Glycerite of Hydrogen Peroxide on Mycobacterium Tuberculosis (var. Hominis), Science **105**:312-313, 1947.

3. Slanetz, L. W., and Brown, E. A.: Studies of the Effect of Glycerite of Hydrogen Peroxide upon the Numbers of Oral Microorganisms, J. Dent. Research **25**:223-230, 1946.

The following bacterial species are reported on in this paper: Staphylococcus aureus (FDA 209); Staphylococcus albus, coagulase positive; Staphylococcus pharyngis; Streptococcus liquefaciens, alpha hemolytic; a beta hemolytic streptococcus; a diphtheroid; Bacillus subtilis; Escherichia coli communior; Proteus mirabilis; Pseudomonas aeruginosa, and Aerobacter cloacae. The organisms were, with the exception of Staph. aureus, which came from the Food and Drug Administration laboratory, strains freshly isolated from lesions of clinical interest. Other strains of organisms and of streptococci and staphylococci in particular were examined. The report of only one of each is included, since all gave essentially equivalent results. The method is that described in a previous paper by Brown, Krabek and Skiffington [4] and is a modification of the Oxford cup method of Abraham, Chain and their co-workers [5] and of the United States Food and Drug Administration cup plate method.[6]

DESCRIPTION OF METHOD

The modified method consists essentially of the introduction of 0.2 cc. of the solution to be tested into glass or porcelain cylinders with paraffined rims, placed on agar preinoculated with the test organism. The rims of the cylinders must be paraffined to prevent creeping of certain solutions over the edge. Dextrose agar was used in order that growth might be obtained with the greatest number of strains, since some pathogenic organisms fail to grow freely, if at all, on the Food and Drug Administration medium. The melted agar was inoculated with 0.2 cc. of an undiluted 22 to 26 hour dextrose broth culture for each 25 cc. of medium, and placed in the 100 mm. Petri dishes with porous covers. Ten per cent normal horse serum was added to the dextrose agar in an additional number of plates to provide organic matter and to simulate more closely a serous lesion.

After incubation at 37 C. for about eighteen hours, subcultures of approximately 3 mm. cross section were taken at intervals of 1 to 3 mm. radially from the edge of the cylinder and placed in modified Brewer's thioglycollate medium.[7] The subculture tubes were incubated at 37 C. until growth occurred or for at least seven days. Before the subcultures were discarded, those tubes showing no growth were reinoculated with a small inoculum (50 organisms or fewer) of the same strain tested and incubated for three days or less, if growth occurred sooner. This technic indicated that the test solution was not carried over into the subculture in amounts that were inhibitive to the growth of normal organisms.

After the subculture had been made, the distance to the outer edge of the clear zone (if any) from the outer edge of the cylinder was measured to the nearest

4. Brown, E. A.; Krabek, W. B., and Skiffington, R. E.: Glycerite of Hydrogen Peroxide: I. Comparison of Its Bacteriotoxic Action with That of Mercurial Solutions, J. Bact. **53**:793-799, 1947.

5. Abraham, C. P., and others: Further Observations on Penicillin, Lancet **2**:177-189, 1941.

6. Ruehle, G. L. A., and Brewer, C. M.: United States Food and Drug Administration Methods of Testing Antiseptics and Disinfectants, circular 198, United States Department of Agriculture, 1931.

7. Baltimore Biological Laboratories, 1640 Gorsuch Avenue, Baltimore 18.

TABLE 1.—*Comparison of Action of Glycerite of Hydrogen Peroxide and Some Aural Antiseptic Solutions on Gram-Positive Organisms**

Solutions	Staph. Aureus				Staph. Albus				Staph. Pharyngis				Str. Liquefaciens				Beta Hemolytic Streptococcus				Diphtheroids			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Hydrogen peroxide, 1.46%, with urea (no oxine)	14	15	13	10	18	18	11	12	12	12	9	9	10	8	8	8	14	27	12	18	15	13	7	5
Hydrogen peroxide, 1.46%, with urea (with oxine)	13	13	13	11	18	18	14	17	13	10	9	12	11	15	8	12	15	35	14	23	16	12	14	11
Hydrogen peroxide, 1.5% (no urea, no oxine)	13	10	6	8	18	10	11	12	10	4	7	7	12	13	6	5	16	25	14	22	12	13	9	6
Hydrogen peroxide, 1.5%, with oxine (no urea)	13	15	7	3	22	23	20	17	12	15	7	12	11	14	9	10	16	32	15	28	9	12	5	5
Oxine (8-hydroxyquinoline)	10	6	7	7	15	14	10	11	5	4	2	3	6	3	0.5	2	5	6	2	3	16	8	6	5
"Auralgan"	2	3	2	2	6	6	4	5	1	3	1	3	0	0	0	0	3	4	0	12	2	5	0	0
"Otosmosan"	6	4	4	4	5	3	3	3	4	3	2	4	6	4	3	4	10†	14	0	13	10	4	8	5
"Otomide"	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	2	3	2	2	0	0	2	3

* Zones of bactericidal activity are measured in millimeters from the edge of the cup to the edge of the clear zone. A indicates apparent visible zone of inhibition (no serum); B, zone as determined by subculture (no serum); C, apparent visible zone of inhibition (10 per cent serum), and D, zone as determined by subculture (10 per cent serum).

† Opaque zone, indicating precipitation.

TABLE 2.—*Comparison of Action of Glycerite of Hydrogen Peroxide and Some Aural Antiseptic Solutions on Gram-Negative Organisms**

Solutions	B. Subtilis				Esch. Coli				P. Mirabilis				Ps. Aeruginosa				A. Aerogenes			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Hydrogen peroxide, 1.46%, with urea (no oxine)	13	13	7	7	5	5	7	5	7	6	7	6	4	3	4	5	6	6	6	9
Hydrogen peroxide, 1.46%, with urea and oxine	13	13	11	11	7	6	6	7	10	9	7	7	5	3	4	4	8	10	8	8
Hydrogen peroxide, 1.5% (no urea, no oxine)	14	13	9	4	3	3	7	6	5	3	5	6	1	2	1	3	6	6	6	6
Hydrogen peroxide, 1.5%, with oxine (no urea)	13	13	11	14	4	5	3	3	7	6	6	3	5	3	4	3	6	6	7	7
Oxine (8-hydroxyquinoline)	15	16	13	10	4	3	0	0	7	3	2	3	0	3	0	3	6	5	0	3
"Auralgan"	3	3	2	3	0	0	0	0	0	0	0	0	0	0	0	0	6	3	2	3
"Otosmosan"	8	3	4	3	7	4	7	4	3	4	2	3	0	0	4	3	0	0	2	3
"Otomide"	0	0	3	3	0	0	0	0	0	0	2	3	7	3	6	3	1	3	0	0

* Zones of bactericidal activity are measured in millimeters from the edge of the cup to the edge of the clear zone. A indicates apparent visible zone of inhibition (no serum); B, zone as determined by subculture (no serum); C, apparent visible zone of inhibition (10 per cent serum), and D, zone as determined by subculture (10 per cent serum).

0.5 mm. and recorded for each test. At the same time, the distance from the edge of the cylinder to the inner and the outer edge of the indentation left by the removal of material for subcultures was measured and recorded. Because of limitations of space the accompanying tables show only the average distal measurements of the subcultures closest to the cup which showed growth in a subculture tube. This procedure, of course, favors the solution tested. At least three, and in many cases more, replicate tests were made on each antiseptic solution. The values in the tables have been rounded off to the nearest whole number, since this is sufficient for comparative purposes. The first table lists the zones obtained with the gram-positive organisms and the second those obtained with the gram-negative organisms.

The solutions of glycerite of hydrogen peroxide all showed pronounced bacteriotoxic action on both gram-positive and gram-negative organisms. The clear zones resulting from their application were larger than those obtained with the three aural solutions with which comparison was made. The addition of oxine to peroxide solutions resulted in somewhat greater bacteriotoxic activity in the presence of serum, but not much difference in the absence of serum. Alone, oxine in glycerin appeared to have activity equal to or greater than that of the three aural solutions against the organisms tested.

Urea was found by Wilson [8] and others to be bacteriotoxic in aqueous solutions of certain concentrations and apparently bactericidal in stronger solutions, when permitted to act over a relatively long period. It does not appear to have any significant effect when tested by an agar plate method, possibly owing to a tendency to diffuse widely, resulting in an ineffective dilution. That it does diffuse is indicated by a change in colony appearance with some organisms. The healing action of urea is, of course, dependent on living cells, as is much of the activity of the sulfonamide drugs. The latter are known for their lower activity in in vitro tests. The solutions of glycerite of hydrogen peroxide do not depend on the mediation of living cells for their bactericidal activity, and thus have an additional advantage over substances which do.

Since the products of decomposition of the peroxide-glycerin solution are, with the exception of the oxine, normally present in the body, there is less likelihood of unfavorable reaction with them than with substances foreign to the tissues. No allergenic action, and essentially no irritation, was observed in the use of the peroxide solutions of this type, as reported by Brown.[9] Oxine has been used in many preparations

8. Wilson, W. J.: Pleomorphism, as Exhibited by Bacteria Grown on Media Containing Urea, J. Path. & Bact. **11**:394-404, 1906.

9. Brown, E. A.: Studies on Tissue Tolerance to a New Glycerol Peroxide Antiseptic Solution, Ann. Allergy **4**:33-39, 1946.

and appears to have no unfavorable action in the amounts present in the hydrogen peroxide–glycerin solutions. It was stated by Haas [10] to favor healing.

SUMMARY

An in vitro comparison was made by means of a modified agar cup plate method of the bacteriotoxic and bactericidal effects of several hydrogen peroxide–glycerin solutions and of three aural antiseptics (auralgan,® otosmosan® and otomide®) on six gram-positive and four gram-negative organisms.

The peroxide solutions consisted of hydrogen peroxide (1.5 per cent) as derived from the solution of urea peroxide (4 per cent) in glycerin, or hydrogen peroxide (92 per cent) diluted to 1.5 per cent in glycerin. Oxine (8-hydroxyquinoline) was added to some of the solutions as an added stabilizer. The peroxide solutions showed bacteriostatic and bactericidal activity against all organisms tested to an appreciably greater extent than did the three proprietary aural preparations.

75 Bay Street Road.

10. Haas, A.: Entzündungshemmung und Umstimmung durch Chinora im Experiment, München. med. Wchnschr. **79**:142-143, 1932.

PENICILLIN-SULFANILAMIDE FILLING AND PRIMARY SUTURE IN SIMPLE MASTOIDECTOMY

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SIMPLE mastoidectomy is performed mostly to eradicate infection in the mastoid bone, to prevent or treat intracranial complications and to stop the discharge from the middle ear—in other words, to save the patient's life and hearing.

Since 1873, when Schwartze and Eysell [1] described their systematic operation, otologists have followed that method in principle, with slight individual modification. On the other hand, they have tried many different procedures to shorten the time of hospitalization, the time of healing of the postaural wound and, in particular, the time taken for the discharge from the ear to stop. Because, the longer that time is, the greater is the loss of hearing and vice versa.

To achieve the aforementioned ends, I have tried the following methods during the last twenty-one years.

METHODS

METHOD 1.—Before sulfanilamide was used locally in septic wounds, I was in the habit, after complete exenteration of the mastoid cells, of filling the mastoid cavity with iodoform and 10 per cent ether, instead of the usual iodoform paste, and stitching the mastoid wound completely, leaving a rubber catheter in the most dependent part of the wound. With this method the average time required for the wound to heal and for the aural discharge to stop was three weeks.

METHOD 2.—After sulfanilamide had been used with good results, such as those obtained by Jensen and his associates [2] in the treatment of compound fractures with powdered sulfanilamide, I modified my procedure, filling the mastoid cavity with sulfanilamide powder, after having flushed it with ether, and then stitching the wound completely, leaving a rubber catheter drain. When this modification was put into effect, the average time for the wound to heal and for the aural discharge to stop was two weeks, that is, one week less than with method 1. I used this method from 1939 to November 1946, when the intramuscular administration of penicillin was added, with results in 12 cases as shown in table 1.

From the University Hospital.

1. Schwartze, H., and Eysell, C. G. A.: Ueber die künstliche Eröffnung des Warzenfortsatzes, Arch. f. Ohrenh. **7**:157-187, 1873.

2. Jensen, N. K.; Johnsrud, L. W., and Nelson, M. S.: Local Implantation of Sulfanilamide in Compound Fractures: Preliminary Report, Surgery **6**:1-12 (July) 1939.

METHOD 3.—With this third method, namely, administration of ether, filling the cavity with sulfanilamide powder, complete suturing of the wound and insertion of a rubber drain, in addition to the intramuscular administration of penicillin (20,000 units every three hours), the results were dramatic (table 1). The maximum time of healing of the postaural wound and of cessation of the aural discharge was five days in all cases in which this method was used.

TABLE 1.—*Results of Treatment of Acute Surgical Mastoiditis by Local Application of Sulfanilamide, General Administration of Penicillin and Primary Suture*

Case	Sex	Age	Diagnosis	Pathologic Observations	Time Required for Healing, Days	Days of Hospitalization	Healed by First Intention
1	F	20 yr.	Mastoiditis; labyrinthitis (left)	Subperiosteal abscess; pus granulations in antrum and mastoid cells	5	21	+
2	M	15 yr.	Mastoiditis (right)	Subperiosteal abscess; pus granulations in antrum and cells; extradural abscess	5	30	+
3	M	2 yr.	Mastoiditis (right)	Subperiosteal abscess; pus granulations in antrum and cells	5	11	+
4	F	3 mo.	Mastoiditis (right)	Subperiosteal abscess; fistula leading to antrum filled with granulations	5	12	+
5	F	4 mo.	Mastoiditis (right)	Subperiosteal abscess; granulations and pus in antrum	5	12	+
6	M	55 yr.	Mastoiditis (right)	Subperiosteal abscess; pus granulations in antrum and cells; extradural abscess	5	22	+
7	M	50 yr.	Mastoiditis (right)	Subperiosteal abscess; pus granulations in antrum and cells	5	38	+
8	M	3 yr.	Mastoiditis (right)	Subperiosteal abscess; pus granulations in antrum and cells	5	21	+
9	M	20 yr.	Mastoiditis (right)	Subperiosteal abscess; granulations in antrum and cells	5	23	+
10	M	24 yr.	Mastoiditis (left)	Subperiosteal abscess; pus granulations in antrum and cells	5	12	+
11	M	6 mo.	Mastoiditis (left)	Subperiosteal abscess; granulations in antrum and cells	5	14	+
12	M	10 yr.	Mastoiditis (right)	Subperiosteal abscess; pus granulations; extradural abscess	5	37	+

But, as the intramuscular administration of penicillin in doses of 20,000 units every three hours, day and night, for five days was tiring both to the patient and to the hospital staff, I thought of trying the local application of penicillin in the mastoid wound, as suggested by Johnson.[3] He recommended the insufflation of 10,000 units every eight hours for four days into the mastoid cavity through a ureteral catheter, after mastoidectomy. This method still seemed trying to both

3. Johnson, L. F.; Weinstein, L., and Spence, P. S., Jr.: Penicillin and Primary Suture in Treatment of Acute Surgical Mastoiditis, Arch. Otolaryng. **41**:408-412 (June) 1945.

the patient and the hospital staff; also there was a risk, though slight, of a secondary infection being introduced into the mastoidectomy wound.

TABLE 2.—*Results of Treatment of Acute Surgical Mastoiditis by Local Application of Sulfanilamide and Penicillin and Primary Suture*

Case	Sex	Age	Diagnosis	Pathologic Observations	Time Required for Healing, Days	Days of Hospitalization	Healed by First Intention
1	M	56 yr.	Mastoiditis (left)	Subperiosteal abscess; pus granulations in antrum and mastoid cells; extradural abscess so big as to hold 10 Gm. of sulfanilamide	5	32	+
2	M	47 yr.	Mastoiditis (right)	Subperiosteal abscess; pus granulations in antrum and cells; extradural abscess	5	60	+
3	M	8 yr.	Mastoiditis (left)	Subperiosteal abscess; granulations in antrum and cells; extradural abscess	5	30	+
4	M	20 yr.	Mastoiditis (right)	Subperiosteal abscess; pus granulations in antrum and cells	5	30	+
5	M	2 yr.	Mastoiditis (right)	Subperiosteal abscess; pus granulations in antrum and cells	5	32	+
6	F	50 yr.	Mastoiditis (left)	Subperiosteal abscess; pus granulations; extradural abscess	5	23	+
7	M	30 yr.	Mastoiditis (right); facial paralysis; rhinoscleroma	Granulations in antrum and cells; facial nerve found exposed	5	53	+ Facial nerve paralysis cured; rhinoscleroma cured by radium
8	M	6 yr.	Mastoiditis (right) fistula behind auricles from previous incision done outside hospital	Fistula leading to antrum full, with granulations, and pus also in the mastoid cells	5	33	+
9	F	8 yr.	Mastoiditis (right)	Subperiosteal abscess; pus granulations in antrum and cells	5	19	+
10	F	6 mo.	Mastoiditis (left)	Subperiosteal abscess; granulations in antrum	5	9	+
11	M	23 yr.	Mastoiditis (left)	Subperiosteal abscess; extradural abscess	5	20	+
12	F	23 yr.	Mastoiditis (left)	Subperiosteal abscess; extradural abscess	5	10	+
13	F	11 mo.	Mastoiditis (left)	Subperiosteal abscess; pus granulations in antrum and cells	5	13	+
14	M	1 yr.	Mastoiditis (left)	Subperiosteal abscess; granulations in antrum and cells	5	20	+
15	M	4 yr.	Mastoiditis (left)	Subperiosteal abscess; granulations in antrum and cells	5	16	+

METHOD 4.—It occurred to me then to use both penicillin and sulfanilamide powder in the mastoidectomy wound. In view of the fact that the type of organ-

isms causing the mastoiditis is usually unknown before operation, this method has an advantage, for with it there is a desired effect on the organisms susceptible to sulfanilamide as well as on those sensitive to penicillin. Moreover, when this method is used, the discomfort of the injections of penicillin is avoided.

In all the 15 consecutive cases in which I used this method, as is shown in table 2, the postaural wound and the external ear were dry on the fifth day after operation, when the dressings were first removed. Neither local nor general bad effects following use of this method have been encountered in any of the cases. The hearing was not affected more than was to be expected with the pathologic condition in the middle ear, produced by the disease before operation.

Procedure.—The procedure I employ for the local use of sulfanilamide and penicillin in the mastoid cavity is as follows: The external meatus is thoroughly dried, then sucked with Siegle's speculum and dried again. Tincture of iodine, 5 per cent, is poured in and then swabbed out with alcohol, and the gauze is packed in. The auricle and the area of operation are painted with tincture of iodine and swabbed again with alcohol to remove the excess.

The mastoid cells and products of inflammation are thoroughly exenterated, care being taken to scrape the aditus and the attic, as Professor Ruttin, of Vienna, suggested to me. In my method, the part of the mastoid tip lateral to the digastric ridge is removed, and not the whole tip. The mastoid retractors are removed. Bleeding vessels are secured, and a thin silver wire, to serve as a drain, is put into the mastoid cavity, with one end in the maxillary sinus and the other stitched to the lowest part of the wound, after a loop has been made in the wire. I prefer silver wire to rubber because it does not take a great deal of space and because it is smooth and does not irritate the wound tissue, not even the dura. It acts as a drain for serum or pus if the wound becomes septic. Such a mishap has not yet taken place in any of my cases.

The aditus of the mastoid cavity and the external meatus are flushed with ether and dried by swabbing. The advantage of ether is that it dries quickly and completely.

Penicillin (100,000 units) is dissolved in 1 or 2 cc. of isotonic solution of sodium chloride, according to the size of the mastoid cavity, and the solution is then withdrawn into a graduated syringe. The prepared solution is poured into the mastoid cavity, care being taken that the needle of the syringe is directed toward the aditus so that some of the penicillin solution enters the attic and the middle ear. A few drops are put into the external meatus. No after-reaction in the middle ear has followed this method. Five grams of sulfanilamide powder, previously sterilized in a test tube at 140 C. for two hours in dry heat, is gradually poured into the mastoid cavity, the powder being stirred all the time with the solution of penicillin. Thus a uniform mixing takes place, and a sort of cream of penicillin, sulfanilamide and a slight amount of blood is formed. A wick of gauze is dipped into the cream and then packed into the external meatus.

The postaural wound is completely stitched, except for the site of entrance of the silver wire drain, which is 2 mm. thick. While the wound is being stitched, the cream will be seen oozing out from between the stitches. A roll of gauze is put over the stitched wound and pressed into place by the auricle so that the mastoid cavity beneath will be obliterated as much as possible. The operative field is then dressed in the usual way.

Five days after the operation, when the dressings are removed for the first time, the wound and the external meatus are found dry. The silver wire and the stitches are then removed. The wound and the external meatus are dusted with sulfanilamide powder and redressed. On the seventh day after operation, the

dressings can be discarded, and the patient can be discharged as cured, with both the postaural wound and the middle ear dry. However, I have kept the patients in the hospital for at least a month so that they can be under observation.

In all the cases in which this method was used, the wounds healed by first intention in five days without either local or general bad effects and with good cosmetic results. The report of the cases is summarized in tables 1 and 2 to facilitate reference.

ANALYSIS OF DATA

Age.—The youngest patient in either group was 3 months old, and the oldest, 56 years. Consequently, age is not a factor to be considered, since in the young, who were without mastoid cells, and in the old, who had mastoid cells, the course of healing was the same.

Pathologic Changes.—Operation revealed subperiosteal abscesses in all cases. The mastoid bones showed definite cellular destruction, free pus and granulations. An extradural abscess was present in 9 cases. In 1 (case 1, table 2) the extradural abscess was so extensive that the cavity at the end of the operation held 10 Gm. of sulfanilamide, instead of the usual 5 Gm. The facial nerve was found exposed in 1 instance (case 7, table 2), with facial paralysis; so the presence of the exposed dura is not a contraindication to primary suture.

Bacteriologic Findings.—Bacteriologic examination was not feasible in all cases. In the cases in which it was done, the usual streptococci, staphylococci and pneumococci were present. The colon bacillus was present in 1 case.

Time of Healing.—In both groups, the postaural wound was healed and the middle ear was dry on the fifth postoperative day. The patients could be discharged from the hospital as cured on the seventh day after operation, but they were kept in the hospital longer, with the intention that they remain under observation.

SUMMARY

Simple mastoidectomy is done to save the patient's life and hearing.

Since Schwartze, in 1873, described his operation, otologists have followed his technic in principle.

On the other hand, various methods have been tried to shorten hospitalization and the time of healing.

In this report a method is described which was used in treating acute surgical mastoiditis by sulfanilamide-penicillin filling and primary suture. All the 15 patients thus treated were cured, with excellent plastic results and without any general or local bad effects. The method is recommended in all cases of acute surgical mastoiditis.

University Hospital.

NECROSIS WITHIN THE PTERYGOPALATINE FOSSA

Operation and Recovery

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AND
ARTHUR J. FISCHER, M.D.
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THE PTERYGOPALATINE fossa is of importance to the rhinolaryngologist; yet seemingly few men have a thorough understanding of it, and fewer still have been interested enough or challenged enough to make contributions to the literature concerning it. Pathologic conditions arising in this fossa occur rarely; at least reports in the journals would so indicate. However, many cases have undoubtedly gone unrecognized and ended fatally, with a terminal diagnosis of some intracranial condition. As yet no definite syndrome has been established which would direct attention to pathologic conditions in this region. Much confusion still exists as to the nomenclature.

A number of the older textbooks have referred to this fossa as the sphenomaxillary, the pterygomaxillary and the sphenopalatine, but after investigating articles by Gray,[1] Piersol,[2] Turner and co-workers,[3] Barnhill and Mellinger,[4] Jackson and Jackson,[5] Lederer,[6] Cunningham [7] and others, and after carefully examining numerous specimens in the dissecting laboratory, I have come to the conclusion that these terms are all synonymous. Therefore, in this paper I shall refer to the fossa as the pterygopalatine.

From the Department of Otolaryngology, University of Pittsburgh.

1. Gray, H.: Anatomy of the Human Body, revised and reedited by W. H. Lewis, ed. 23, Philadelphia, Lea & Febiger, 1936, p. 129.

2. Piersol, G. A.: Human Anatomy, ed. 2, Philadelphia, J. B. Lippincott Company, 1908, vol. 1, pp. 227-228.

3. Turner, A. L., and others: Diseases of Nose, Throat and Ear for Practitioners, and Students, ed. 3, Baltimore, William Wood & Company, 1932, p. 13.

4. Barnhill, J. F., and Mellinger, W. J.: Surgical Anatomy of the Head and Neck, ed. 2, Baltimore, William Wood & Company, 1940, p. 399.

5. Jackson, C., and Jackson, C. L.: Diseases of the Nose, Throat, and Ear, Including Bronchoscopy and Esophagoscopy, Philadelphia, W. B. Saunders Company, 1945, pp. 71-72.

6. Lederer, F. L.: Diseases of the Ear, Nose and Throat: Principles and Practice of Otorhinolaryngology, ed. 2, Phliadelphia, F. A. Davis Company, 1939, p. 745.

7. Cunningham, D. J.: Text-Book of Anatomy, edited by A. Robinson, ed. 5, New York, William Wood & Company, 1923, p. 165.

It is located just behind the posterior wall of the antrum and below the apex of the orbit. It is the shape of an inverted cone and measures 1.5 to 2 cm. in length, and 0.7 to 1 cm. at its base; the apex is continuous with the pterygopalatine canal. It is bounded above by the under surface of the sphenoid bone and the orbital process of the palatine bone. Anteriorly is the infratemporal surface of the maxilla or, more correctly, the extreme posterior wall of the maxillary sinus; medially is the base of the pterygoid process and the lower part of the anterior surface of the great wing of the sphenoid bone, with the medial wall formed by the vertical part of the palatine bone and its orbital and sphenoidal processes. Laterally, it is limited by the temporalis muscle and other soft structures which occupy the infratemporal fossa.

Five important foramens open into it:

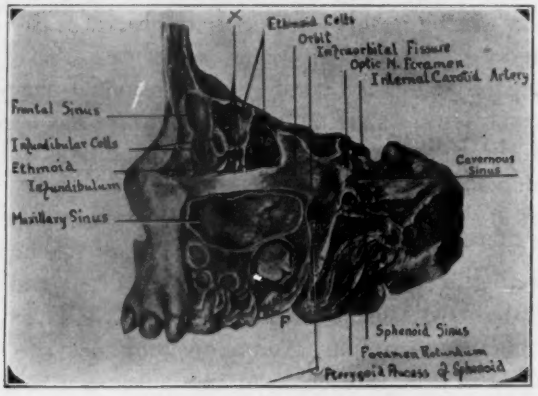

Fig. 1.—The wide exposure shown here is, of course, from a laboratory dissection. It, or some modification, may be employed when cancer or some other destructive process minimizes the importance of postoperative disfigurement. However, the approach described in the text was made according to the Caldwell-Luc technic.

1. Foramen rotundum, located on the upper portion of the posterior wall. This structure conveys the maxillary nerve or the second division of the trigeminal (fifth) nerve.

2. Pterygoid (vidian) canal, located on the posterior wall about 0.5 cm. below and just medial to the foramen rotundum. It contains the pterygoid (vidian) nerve and artery.

3. Pharyngeal canal, located about the middle of the fossa on the posterior wall near its junction with the medial wall. It conveys the pharyngeal nerve and a pharyngeal branch of the internal maxillary artery.

4. Sphenopalatine foramen, located at the upper portion of the medial wall of the fossa. The sphenopalatine artery and vein and the spheno-

palatine nerve with its superior and inferior nasopalatine branches emerge from this foramen.

5. The pterygopalatine canal is the inferior continuation of the apex of the pterygopalatine fossa. Through it pass the descending palatine artery and vein and the anterior palatine nerve.

In addition to the foramens mentioned, there are often several small ones on the inferior medial surface which convey small palatine vessels and nerves.

This area contains three important structures:

1. The maxillary nerve.
2. The sphenopalatine ganglion.
3. The internal maxillary artery.

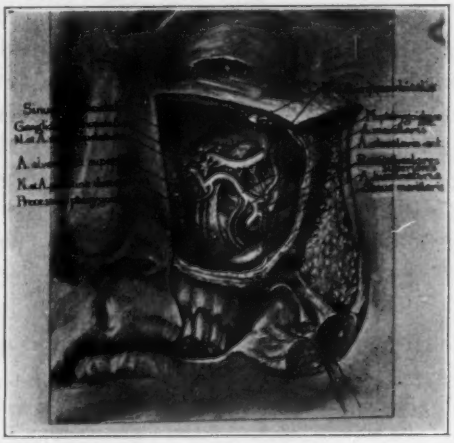

Fig. 2.—Specimen illustrating the anatomy of the pterygopalatine fossa. (The illustration is reproduced with the permission of Dr. J. Wallace Davis, speaking for Dr. Warren B. Davis and W. B. Saunders Company.)

The maxillary nerve emerges from the foramen rotundum, courses in an anterolateral direction and enters the infraorbital canal as the infraorbital nerve. The sphenopalatine ganglion lies just in front of the opening of the vidian canal, a few millimeters below and medial to the maxillary nerve. The lateralmost structure is the internal maxillary artery, which emerges from the external border and enters the infraorbital foramen as the infraorbital artery.

Behr [8] reported on a complex of symptoms involving the maxillary and abducens nerves caused by cancers in the maxillary and sphenoid sinuses. He stated that these nerves are in closer relationship here than they are anywhere else in the course of the abducens nerve.

8. Behr, C.: Zur topischen Diagnose der Abduzenslähmung, Ztschr. f. Augenh. **55**:293-307, 1925.

There are differences of opinion in regard to isolated interruptions of conduction of the motor or sensory nerves which pass through the superior orbital fissure. Custodis [9] made that point in commenting on Behr's [8] article. However, this close relationship may explain the diplopia of which my patient complained when this condition began.

The anatomic description shows clearly how infection may enter and be transmitted to important and vital structures. Trauma is an important etiologic factor, as illustrated by the cases of Negus [10] and Schonfeld.[11] Negus' description is that of a case in which a high explosive shell passed through the posterior wall of the antrum to lodge there. Schonfeld [11] described a case in which phlegmon was produced in this region by a lollipop stick that had penetrated the hard palate. Infection spread up the pterygopalatine canal and caused an abscess in the fossa. This, in turn, resulted in retrobulbar cellulitis, exophthalmos and fixation of the eyeball, with the infection extending along the maxillary nerve through the foramen rotundum into the middle cranial fossa. A localized meningitis resulted, together with encephalitis and epidural abscess. The outcome was that the patient died fourteen days after the injury

Theissing,[12] in 1939, described a case in which phlegmonous abscess occurred in a 27 year old woman subsequent to extraction of both upper wisdom teeth. He approaches the abscess by way of the transantral route, removing the posterior wall of the antrum.

Infection is not the only indication for surgical exposure of this region. Intractable sphenopalatine ganglion neuralgia can be relieved by removal of the ganglion. In cases of uncontrollable hemorrhage of branches of the internal maxillary artery, the artery can be isolated and ligated.

There are four main surgical approaches to this area:

1. Transorbital. Carnochan,[13] in 1858, followed the infraorbital nerve from its exit at the infraorbital foramen to the foramen rotundum. His incision was made through the cheek, and exposure of the nerve necessitated sacrifice of the orbital floor.

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9. Custodis, E.: Anatomische Untersuchungen und klinische Beobachtungen zum Syndrom der Erkrankungen der Fossa pterygo-palatina (Behr), Ztschr. f. Augenh. **95**:259-268, 1938.

10. Negus, in Jackson and Jackson.[5]

11. Schonfeld, W. A.: Phlegmon of the Pterygopalatine Fossa Following Injury to Hard Palate with Lollipop Stick, J. A. M. A. **108**:197 (Jan. 16) 1937.

12. Theissing, G.: Eröffnung der Flügelgaumengrube durch die Kieferhöhle bei aszendierender dentaler Komplikation, Arch. f. Ohren-, Nasen- u. Kehlkopfh. **146**:362-366, 1939.

13. Carnochan, J. M.: Exsection of the Trunk of the Second Branch of the Fifth Pair of Nerves, Beyond the Ganglion of Meckel, for Severe Neuralgia of the Face, Am. J. M. Sc. **35**:134-143, 1858.

2. Transzygomatic. Frazier [14] described a surgical procedure in which he removed the zygomatic arch and approached the fossa by way of the pterygomaxillary fissure.

3. Transpalatal. Averbukh and associates [15] in 1935, described an approach made through the hard palate in the region of the posterior palatine (pterygopalatine) foramen.

4. Transantral. Sewall,[16] in 1936, described what seems to me to be the most satisfactory approach. His description of the operation is as follows:

> The Caldwell-Luc technique is used in opening widely through the canine fossa into the antrum, and from the antrum under the inferior turbinate into the nose. The mucosal lining of the posterior wall of the antrum is circumscribed by an incision down to the bone and is removed. The rest of the mucosa is not disturbed unless disease indicates the necessity for its removal. The posterior bony wall of the antrum is next removed, and the periosteum enclosing the contents of the pterygopalatine fossa exposed. The periosteum is incised carefully and the underlying parts dissected with blunt instruments.

Shortly after reading Sewall's [16] article, I was called in consultation to see a man, J. M., who, because of well timed surgical intervention, is alive and well today.

He was first admitted to St. Francis Hospital to the neurologic service of Dr. George Wright and Dr. Harold Mitchell, March 19, 1937, complaining of slight swelling lateral to his right eye, diplopia, bulging of the right eye itself, pain on motion of the jaw and inability to chew solid food. His trouble began five months prior to admission, when his right eye turned inward overnight. He consulted an ophthalmologist at that time, who told him that the nerves to that eye were paralyzed, but gave no treatment and within a month the eye gradually resumed a central position. However, the diplopia persisted.

Physical examination revealed a rather acutely ill white man, aged 25 years. There was a moderate amount of swelling of soft tissue of the right anterior temporal region. Outward movement of the right eye was limited to just beyond the midline. There was marked proptosis of the right eye. The right cornea, pupil and media were normal, but the margins of the disk were blurred, and the retinal vessels were dilated and tortuous. The left eye and both visual fields were normal. Diplopia was marked. The Wassermann and Kahn tests of the blood were negative for syphilis. The rest of the physical and neurologic examination offered no further contribution to the diagnosis.

A roentgen examination of the skull was made on admission by Dr. Leslie Osmond: "There is almost complete loss of the entire right orbit with the exception of the bone around the superior orbital fissure and the extreme superior

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14. Frazier, C. H.: Surgical Approach to the Sphenopalatine Ganglion, Ann. Surg. **74**:328, 1921.

15. Averbukh, S. S.; Brevda, I. S.; Lubotsky, D. N., and Semenova, O. S.: Palatine Access to Ganglion Sphenopalatinum and to Second Branch of Trifacial Nerve, Ann. Surg. **101**:819-826, 1935.

16. Sewall, E. C.: Surgical Removal of Sphenopalatine Ganglion, Tr. Am. Laryng. A. **58**:45-54, 1936; Ann. Otol., Rhin. & Laryng. **46**:79-86, 1937.

portion of the orbit. The apex of the pyramidal orbital bony outline is completely eroded. There is a lack of the plate of the frontal extension of the zygomatic bone, indicating erosion extending through the lateral portion of the orbit into the fossa posterior to the zygoma. There seems to be erosion into the right ethmoid bone. The findings indicate some form of tumor."

Dr. Samuel S. Allen and Dr. J. F. Grunnagle, of the neurosurgical department of the University of Pittsburgh, were called in consultation, and, on March 25, a biopsy specimen of the tumorous mass in the right temporal region was taken by Dr. Allen. Microscopic examination revealed adipose tissue and striped muscle. Three days later, Dr. Grunnagle took another biopsy specimen and obtained some muddy brown fluid, which was sent to the laboratory for culture. This was found to be sterile. Two days later, Dr. Grunnagle again operated, using tribromoethanol-ether anesthesia, and found a cystic mass beneath the galea in the right temporal region. He evacuated 6 to 8 ounces (177.5 to 236.5 cc.) of muddy brown fluid, which was again sterile. This resulted in disappearance of the proptosis of the right eye. Operative diagnosis was: "Neoplasm involving the right orbit, right temporal bone and soft tissues in the right temporal region."

The patient was discharged from the hospital, April 8, 1937, slightly improved. Ten days later, April 18, he was readmitted, complaining of headache and severe pains in the right temple. Again there was marked exophthalmos of the right eye, and the skin at the operative site was bulging and tense. Roentgen examination of the skull, April 21, was reported as follows: "No roentgen evidence of any change since the last examination."

I saw the patient for the first time on April 22. Transillumination showed both maxillary antrums clear, the left frontal sinus clear and the right frontal sinus cloudy. The septum was deviated to the left, and no pus was present in the middle meatus. The right inferior turbinate was enormously hypertrophied, boggy and swollen. The ears and the throat appeared normal.

On April 24 Dr. Grunnagle again drained the cystic mass. Two days later the swelling returned, and the entire right side of the face and region of the right eye were markedly edematous. The patient complained of pain in the operative region. By May 6 the swelling was enormous and I was again called in consultation. Although my examination of the right antrum revealed no abnormality, Dr. Wright and Dr. Allen requested that I investigate it surgically.

The appearances were comparable to those of one-sided Paget's disease (osteitis deformans) complicated by the extreme exophthalmos coincident with cavernous sinus thrombosis, and there was presented the picture of an enormous sarcoma of the brain and orbit. The patient was disheartened and fearful that he was left perhaps to pass on his way without anything being done to help him. It was my reading of Sewall's[16] article wich prompted me to operate further on this man.

On May 8 the patient was brought to the operating room, and after tribromo-ethanol-ether anesthesia had been established, the right antrum was opened as in the ordinary Caldwell-Luc operation. We found nothing whatsoever within the maxillary sinus itself and therefore made an opening through the posterior wall into the pterygopalatine fossa. We were gratified to find this area filled with muddy brown fluid, and, in addition, there was greenish necrosis of the pterygoid process of the sphenoid bone. We enlarged the opening on the posterior wall of the antrum until it was about 2 cm. in diameter and then removed all the necrotic bone with forceps. We made an enormous opening in the right lateral nasal wall beneath the attachment of the inferior turbinate. The antrum was packed with compound

tincture of benzoin gauze, the free end protruding from the right nostril. The gingival incision was closed with two black silk sutures.

The patient's response was excellent. The antral packing was removed through the nose on the second postoperative day. On May 13, five days later, the sutures were removed and the antrum irrigated. Two days later, the antrum was again irrigated, and on May 16, eight days after the operation, the patient was discharged from the hospital well on his way to recovery. He was carefully observed in my office for several months after his discharge. He has had no further trouble and has been able to work over a period of nine years since his operation. He even served with the United States Navy during the war.

SUMMARY

The terms "sphenomaxillary fossa," "pterygomaxillary fossa," "sphenopalatine fossa" and "pterygopalatine fossa" are all synonymous.

The anatomy of this fossa, its location, the various structures contained within it and the various openings have all been described in detail. One may see from the description given how infection may enter and how that infection may spread to the orbit, the brain and the soft structures in the infratemporal region.

Various reasons for surgical intervention have been given. Of these reasons, infection is the most urgent. The following symptoms and signs should make the surgeon think of infection in this region: (1) unilateral proptosis; (2) soft tissue swelling in the temporal area of the same side; (3) pain in the distribution of the sphenopalatine ganglion.

Four routes of surgical approach have been given: transorbital, transzygomatic, transpalatal and transantral. Of these, the transantral, described by Sewall,[17] seems to have the greatest advantage.

A case of necrosis of the pterygopalatine fossa with operation and complete recovery has been presented.

In the preparation of this article we had the assistance of Sister M. Laurentine, of St. Francis Hospital, and Dr. George N. Stewart, of the University of Pittsburgh School of Dentistry.

623-4 Union Trust Building.

17. Sewall, E. C.: An Operation for Removal of the Sphenopalatine Ganglion, Ann. Otol., Rhin. & Laryng. **35**:1-22, 1926.

NASAL FRACTURES

An Analysis of One Hundred Cases

OSCAR J. BECKER, M.D.
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OF MORE than 135 cases of recent nasal injuries, fractures were found in 100. An analysis of these 100 cases has led to the formulation of certain principles concerning the management of nasal fractures.

The numerical distribution of the fractures was as follows:

Type of Fracture		Number of Cases
Greenstick fracture		17
Linear fracture		20
Lateral fracture		37
Frontal fractures		14
Partial	11	
Complete	3	
Laterofrontal fracture		10
Fracture from below		2
Total		100

Associated fractures of the maxillary, the frontal bone and/or the zygoma and zygomatic process were present in 8 of these cases.

The type of fracture was determined by the direction of the force of the blow. The severity of the fracture was found to be proportionate to the force of the blow, the type of object encountered and the age of the patient. Because of the variation in the degree of ossification and calcification of the nasal bones, it was found that the force which was required to cause a given degree of bony displacement in children and adolescents was less than that needed to do so in adults. Approximately half the cases in this series were of children and adolescents.

In many cases the nose was shown to have been fractured when the trauma was seemingly minor. An apparently slight injury was often misleading; this caused a serious fracture to be overlooked. Consequently, possibility of fracture in any trauma to the nose was considered until definitely ruled out. If it was impossible definitely to ascertain a fracture in children while there was a reasonable certainty

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that one existed, an exploratory reduction was undertaken with the child under general anesthesia. In almost all cases a fracture was found.

Reduction of the fracture proved a simple procedure when done within the first few hours, i. e., before swelling masked the deformity. If the patient was seen after a fair amount of edema had developed, it was considered advisable to apply cold packs for three or four days in order for the fracture to be properly evaluated.

Reduction of the fracture within the first few days was found to be more important in children than in adults, since the nasal cartilages are softer in children and are affected to a greater degree by scar contractures. Occasionally small hematomas form, involving the perichondrium of the delicate alar or upper lateral cartilages; during absorption there is caused a curling of the cartilage. This state of affairs occurs only occasionally and is similar to perichondritis of the auricle, which results in cauliflower, or boxer's, ear. Early reduction of the fracture and the proper application to the cartilage of an external and intranasal splint with sufficient pressure will prevent curling or scar contractures in the majority of cases.

The cartilages of the adult are firmer and will withstand small hematomas without much curling afterward, thereby allowing one safely to wait up to a week for the edema and masking of the fracture to subside before instituting reduction. No harmful effects to the cartilages were found in almost all adults who were seen even as late as two or three weeks after the fracture had been sustained; but more difficulty was encountered and considerable force was necessary to reduce the fracture at this time. In most patients seen four to five weeks after injury, intranasal incisions and refracture of the nasal bones along the line of fracture with a small septum chisel were necessary. In a few such late cases the fracture was reduced by rocking the bone with an Asch forceps. This procedure was possible because many fractures heal by fibrous union rather than by bony union, and in these types the bone may be shifted with moderate pressure applied in the proper direction.

The effect of trauma on the septal cartilage was found more dangerous to children than to adults. In children, the soft septal cartilage will buckle and deviate, and small hematomas may form under the mucoperichondrium. The hematomas may go unnoticed because of mucosal edema and, if left untreated, may produce callus formation, scar contractures and/or perichondritis, factors which may later produce a deviated septum. Proper and early reduction of the fracture, with subsequent pressure and splinting of the septum, will usually prevent such a sequel.

Occasionally the quadrangular cartilage will be found shifted from the vomerine groove and dislocated. Dislocations of the septum are not as common in fractures seen in adults, probably because of firmer structures and attachments in older persons.

Large septal hematomas were observed in 6 of the cases. Septal hematomas should be evacuated at the time of the reduction of the fracture. This evacuation is done by incision of the mucosa over the hematoma and application of tight intranasal packing supported by pressure from an external splint. If the hematoma is seen late, and abscess formation is already present, evacuation should be done immediately by incision and drainage, followed by chemotherapy or use of antibiotics.

In all but 2 of the 100 cases, immobilization of the fracture was accomplished by intranasal packing and an external splint of dental molding compound (Aufricht[1]). In 2 cases, a headgear type of appliance (Erich and Austin)[2] was required. Once reduced, the nasal bones and cartilages are easily kept in position, for the following reasons: (1) There is no muscular pull on the fragments; (2) the edema of the mucosa and mucoperiosteum partially prevents the fragments from becoming displaced, and (3) the overlying periosteum acts as a splint, holding the fragments together.

Severe fractures of the nose and face, associated with bodily injuries or cerebrospinal rhinorrhea and threatening the life of the patient, were deliberately left untreated until such time as the general condition warranted reduction of the fracture.

DIAGNOSIS

The following seven signs, in order of frequency, were encountered in the series of cases under discussion: epistaxis, swelling of the nasal dorsum, ecchymosis of the eyes, tenderness of the dorsum, roentgenologic evidence of fracture, obvious nasal deformity and crepitus of nasal bones. In most cases, but two or three signs or symptoms were present.

Epistaxis was the commonest of these, since the majority of fractures were compounded by a tear in the underlying mucosa. In many instances the tear was slight and the bleeding minor. The history of bleeding, even of a few drops of blood, was of diagnostic significance. The greenstick fractures, with the mucosa left intact, were the only ones in which there was no bleeding. Linear fractures, which are not always compounded internally by a tear in the mucosa, also

1. Aufricht, G.: Dental Molding Compound Cast and Adhesive Strapping in Rhinoplastic Surgical Procedure, Arch. Otolaryng. **32**:333 (Aug.) 1940.

2. Erich, J. B., and Austin, L. T.: Traumatic Injuries of Facial Bones: An Atlas of Treatment, Philadelphia, W. B. Saunders Company, 1944.

may not be associated with bleeding. The bleeding may be profuse if the fracture tears through the anterior ethmoidal artery or if the septum is fractured low and the main septal branch of the sphenopalatine artery, which runs along the vomer, is torn.

Swelling of the nasal dorsum occurred in 63 of the cases. The degree of edema varied directly with the severity of the injury. Usually there was sufficient edema through the first twenty-four to seventy-two hours to obscure the true extent of the injury. Ice packs hastened the absorption of blood and serum.

Ecchymosis occurred in 55 of the cases. This was due to subcutaneous bleeding and was usually confined to the eyelids and nasal bridge. Sometimes, because of its proximity to the break, one eyelid was found to be more discolored than the other, but this condition was not a constant one. After a lateral blow, the ecchymosis was more pronounced on the side away from the blow. Discoloration of the eyelids usually appeared anywhere from one hour to twenty-four hours after the break. The associated edema of the lids may be sufficient to close them. In a few cases chemosis of the conjunctiva was present. Subconjunctival hemorrhages may also appear, usually around twelve to twenty-four hours later.

Tenderness of the nasal bridge was present to a varying degree in 55 of the cases. Few complaints of pain after the initial break were made, but tenderness on pressure was present. The tenderness was most pronounced directly over the fracture.

The roentgenogram revealed a definite fracture in 53 of the cases. Soft rays were employed to show the fracture and to include the relation of the soft tissues. The majority of patients for whom the roentgenogram revealed a fracture had an obvious nasal deformity. Roentgenograms of the head in the lateral, anteroposterior and Waters positions should be taken, since the fracture will sometimes appear in only one of the views. If the roentgenogram does reveal a fracture, the evidence is conclusive; but if the fracture is not revealed, this fact by no means rules out the possibility of one. For medicolegal reasons, roentgenograms were taken in all cases that might possibly be litigated.

Many children with a nasal deformity were seen weeks or months after a fracture; yet nothing had been done to correct the break when fresh because the roentgenogram had not revealed a fracture.

On initial examination, an obvious bony and/or cartilaginous deformity of the nose was present in but 25 of the cases. After the edema had subsided, i. e., three to four days later, obvious deformities were present in another 15 cases. The nose was depressed or deviated, the deformity depending on the type of injury.

Crepitus of the nasal bones was present in only 15 of the cases, and these were almost always of severe fractures. After forty-eight to seventy-two hours the bones are held together by swollen periosteum, coagulated blood and edematous mucosa, so that the bones can be moved without crepitus.

Nasal obstruction, present in the majority of cases, was due to a fractured septum, edema of the mucous membrane, submucosal hemorrhage or blood clots.

Periorbital emphysema was present in 2 cases of this series.

MECHANICS AND MANAGEMENT

In children, reduction of the fracture was accomplished under general anesthesia, vinyl ether U. S. P. (vinethene®) usually being used. The majority of fractures in adults were reduced with the use of local anesthesia, while a few were reduced with the patient under anesthesia induced by intravenous administration of thiopental sodium (sodium pentothal®). In the adult, a 2 per cent solution of procaine hydrochloride containing epinephrine hydrochloride 1:20,000 was injected along the lateral sides of the nose to anesthetize the fibers of the infratrochlear and infraorbital fibers. A small amount was injected on the dorsum to anesthetize the external nasal nerve. The procaine was massaged into the tissues in order to reduce edema. Five per cent cocaine or 1 per cent tetracaine hydrochloride (pontocaine hydrochloride®) packs were inserted into the nasal cavity to block the sphenopalatine and ethmoidal nerves supplying the septum.

The instruments used were a narrow straight Joseph rasp, a Joseph periosteal elevator and an Asch septum forceps. These were covered with a thin latex rubber tubing. A Kelly forceps, a single hook, a nasal speculum and a bayonet nasal packing forceps were also used. For older fractures a mallet and a straight septum chisel were required.

The Greenstick Fracture.—The greenstick fracture (fig. 1), the most treacherous type because symptoms are mild, accounted for 17 of the fractures in this series.

There was usually no history of epistaxis. Ecchymosis of the eyelids was either absent or slight, being usually confined to the inner canthus of the eye on the side where the blow was directed. The swelling was usually moderate; in many cases, however, it was sufficient to mask any deviation of the nose for two or three days. No crepitus or obvious nasal deformity was present. The septum was bent but not completely broken, so that no tear in the mucous membrane was visible. Nasal obstruction was evident in some cases because of edema of the septum or submucosal hemorrhage. The roentgenogram revealed no abnormality in any case of this type.

It was almost impossible to make a diagnosis in the presence of edema. Only after the edema had subsided did the true state of affairs become visible. A deviation of the nose and a mild curvature of the septum were then noted.

The greenstick fracture in this series was present only in children. A greenstick fracture is likely to be neglected, even though the consequences are a deviated nose and a deviated septum, which become apparent as the child grows. For this reason it was felt that, in all probable cases of greenstick fracture, it is wise to do an exploratory

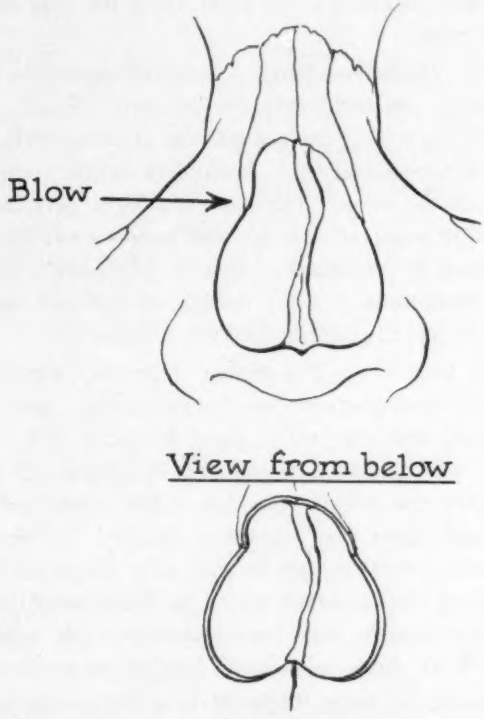


Fig. 1.—Greenstick fracture.

reduction with the child under a safe and short general anesthesia, such as that induced with vinyl ether. In most instances a fracture was found. I have used this rule in all doubtful cases. If evidence of a fracture was questionable or pointed toward a linear fracture without displacement, a waiting period of four to seven days, during which the edema subsided, was instituted before any attempt at reduction.

The mechanics in this type of fracture are essentially an infraction of the nasal bone at its junction with the maxilla. The break is usually incomplete and is never compounded by a tear in the underlying mucosa.

Repositioning of the bones is accomplished by the elevation of the nasal bone on the depressed side with a strong blunt instrument. I found the straight, narrow Joseph rasp, covered with thin rubber tubing, ideal for elevating the bone. It is necessary to complete the fracture before the bone can be replaced into position. This completion is accomplished by the application of force in the reverse of the direction of the fracture by elevation of the bone and by outward rotation. The bone will suddenly be felt to give way. At the same time the bridge is held between the index finger and thumb of the left hand and molded into position. The septum is then held between the two blades of the Asch forceps, moved away from the side of the deviation and slightly elevated.

A packing of petrolatum gauze is inserted tightly in the nose, and the nasal structures are molded to the packing. Small, tight strips of adhesive tape, ½ inch (1.3 cm.) wide, are applied fairly tightly to the dorsum and under the nasal tip. A mold of dental compound is made to fit snugly over the nose. The use of a tight petrolatum pack and the dental molding compound is for the purpose of holding the nasal bones and septum in position. Equally important, however, is the prevention of hematoma. The molding compound and petrolatum packing should be left in position for two to three days.

The Linear Fracture.—The linear fracture, which is a simple fracture without displacement or comminution, constituted 20 of the fractures and was due to a slight blow or fall. This type of simple fracture was fairly common and in almost all cases revealed no deformity after the edema subsided. The symptoms were usually mild, but in many cases they appeared severe. At times the edema of the nasal dorsum was enough to lead to a diagnosis of a depressed fracture because of the apparent width of the nasal bridge. At times ecchymosis of the eyelids was conspicuous. After application of ice compresses for four days, a normal dorsum was noted, as there is no displacement of the bony fragment in a linear fracture. Epistaxis occurred only in those cases in which a tear in the mucous membrane was present. Roentgenograms showed a simple linear fracture either in a lateral view or in Waters position in 8 of the cases.

Treatment consisted in application of ice packs for a few days and observation of the nose for hematoma. If there were considerable edema and a small hematoma under the septum or a collection of blood under the skin of the dorsum, a mold of dental compound was applied and light petrolatum packing inserted intranasally to prevent further swelling and hemotoma. If small hematomas are present under the dorsum, the pressure of the splint will cause more rapid absorption and prevent any curling of the cartilages. Should a large hematoma

be present under the dorsum, either evacuation with a needle or intranasal incision is necessary before application of the molding compound.

The Lateral Fracture.—The lateral fracture was the commonest type of fracture, constituting 37 cases and occurring most frequently in the adult (fig. 2).

The mechanics involved include a depression of the nasal bone fragment under the ascending process of the superior maxilla on the side of the blow. In the majority of cases the nasal bone overrides the maxilla of the opposite side. There are a separation of the nasal bones and a fracture and deviation of the septum to the side opposite the

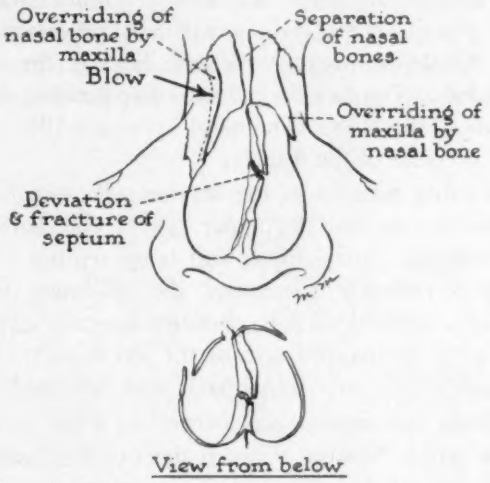

Overriding of nasal bone by maxilla
Blow
Separation of nasal bones
Overriding of maxilla by nasal bone
Deviation & fracture of septum
View from below

Fig. 2.—Lateral fracture.

blow. At times the septal fracture is very severe, so that the upper fragment overrides the lower fragment and projects through a tear in the mucosa.

The external deformity is a lateral deviation of the nose with a depression, due to the locking of the nasal bone under the maxilla, on the side of the blow. A slight depression is apparent over the cartilaginous dorsum of the nose because of the fracture and depression of the septum. In almost all cases in this series, roentgenograms revealed the position of the deformity. The visible nasal deformity usually obviated the necessity for roentgenologic examination. The other characteristic symptoms were almost always present, the epistaxis and edema especially being pronounced.

The optimum time for correction of the deformity lies within the first few hours. If the patient is seen with any considerable edema, it is better to wait three or four days for the edema to subside before

reduction of the fracture. Some of the patients were seen three weeks after the fracture had been sustained, and in the majority no difficulty was encountered in reduction of the deformity.

The depressed nasal fragment must be unlocked and elevated above the maxillary bone. This manipulation was usually accomplished with a straight Joseph rasp by firm pressure upward on the depressed nasal bone. The bone will be felt to click into place when properly elevated. In rare instances the nasal bone is locked tightly under the maxillary bone and cannot be elevated. The Joseph rasp is then placed along the maxillary bone and pushed outward before being used to elevate the nasal bone. In 1 case it was necessary to grasp the maxillary bone with an Asch forceps and rotate it outward (Gillies)[3] before the nasal bone could be repositioned. It is occasionally necessary to use lateral pressure with the thumbs against the base lines of the nose, i. e., over the maxillary bones, to replace the outward displacement of the maxillary bone on the side of the blow. The nasal bones are then molded toward the midline by pressure of the fingers.

By the preceding maneuvers the septum will usually be corrected, for, as the nasal bones and the upper lateral cartilages are elevated, they in turn raise the cartilaginous and bony septum. In most cases this procedure is sufficient to correct the deformity of the septum. Should there be a slight deviation, pressure laterally against the deviation is made with the nasal rasp; in the event of a dislocation, the septum is grasped with an Asch forceps and relocated on the vomer.

In a few cases the septum was overriding itself, making it necessary to place a septal elevator between the two fragments and pry the upper fragment up into position. This operation was usually possible through the tear in the mucous membrane. Fine surgical gut sutures are then inserted through the perichondrium and the mucosa to hold them in position. If the tear in the septal mucosa has healed, incision between the two fragments is necessary before an elevator can be inserted to pry the upper fragments into position. The latter procedure is described by Peer.[4]

Petrolatum packs are inserted and dental molding compound applied externally. This compound is left untouched, with the petrolatum packs in position, for five to six days.

In cases of older fractures, i. e., those which are three to five weeks old, it is still possible in many instances to reduce the lateral fracture

3. Gillies, H. D., and Kilner, T. P.: Treatment of the Broken Nose, Lancet **1**:147 (Jan. 19) 1929.

4. Peer, L. A.: Management of Deformities of the Nose, Ear and Eyelids in Infants and Children, Dis. Eye, Ear, Nose & Throat **2**:166 (June) 1942.

without extensive surgical procedures. In 7 cases the fractures were thus seen late and treated successfully. In 2 cases healing was by fibrous union and the fractures were reduced by methods already described. Five fractures were reduced with the aid of intranasal incisions. An incision is made along the limen vestibuli (the junction of the upper and the lower lateral cartilages) and is continued down to the base of the pyriform rim of the maxillary bone. The skin and periosteum are elevated over the nasal process of the superior maxilla and the nasal bones. A septum chisel is then placed along the fracture line; a few light taps with a mallet will break the early callus and mobilize the bone. An Asch forceps is then inserted through the incision, and the maxillary bone will usually give after some pressure. Traction upward with a straight rasp is then made to elevate the bones, but in 2 instances a septum chisel had to be forced between the two nasal bones at the dorsum of the nose to break their union before they could be elevated.

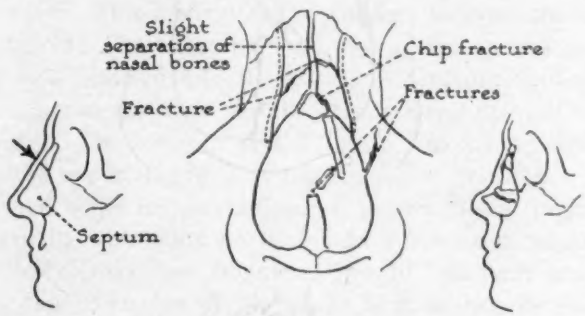


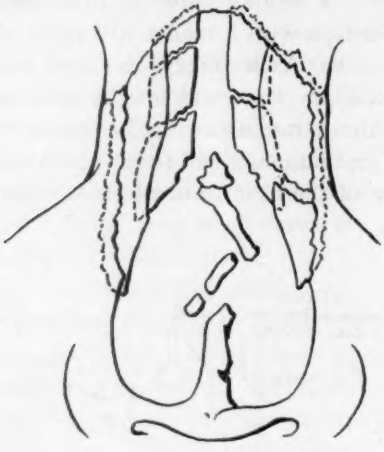
Fig. 3.—Partial frontal fracture.

Frontal Fracture.—Frontal fracture occurred in 14 cases. In 3 cases it was of the crushing type and was classified as complete frontal fracture (fig. 4). In this type the blow is delivered frontally against the nasal bones.

The lower ends of the nasal bones are thin as compared with the structures of the upper nasofrontal area, where the bone is thicker and is firmly attached to the nasal processes of the frontal bone. The frontal fracture usually occurred about midway through the nasal bones and was associated with depression and locking under the nasofrontal processes of the maxillary bones. In some cases the fragments were very depressed and were associated with a corresponding depression of the nasofrontal process on either or both sides. Figure 3 represents the usual type of deformity encountered. Figure 4 represents the severe type of deformity, where the nasofrontal processes also are depressed and fractured. In 1 case, a condition the reverse of the usual type was

present; there was a splaying of the nasal arch over the ascending processes of the maxilla, so that the nasal bones overrode the maxillary bone.

Because of the thinness of the lower end of the nasal bones, chip fragments were frequently broken off and depressed, sometimes tearing through the mucosa of the nose and projecting into the nasal cavity. The bone was never found completely dislodged into the nasal cavity



From below

Fig. 4.—Complete frontal fracture.

because the periosteal layer over the bone is adherent, and this fact prevents the chip from completely detaching itself. Associated fractures of the zygoma and the zygomatic process of the maxillary bone were present in 4 cases and were reduced through the antral approach.

Early reduction is important, more so in this type than in the fractures already described. The reasons are that immobilization of a frontal fracture is more difficult and that the scar tissue which forms

in two weeks may be sufficient to keep the fragments down out of position. After two to three weeks it is difficult to maintain the bones in position, the reason being that the scar in depressed fractures forms across the fragments, and after reduction the scar may reform and exert traction on the fragments to displace them.

In the severe type of fracture the septum was crushed so that cartilage and mucosa were telescoped onto each other. When this condition is corrected months later by a submucous resection, the septum will appear to be of an accordion, or pleated, type, in which two, and sometimes three, layers of cartilage, with mucosa between the layers, will be found. In the usual type of frontal fracture the septum will be found depressed and overriding the inferior segment. In 3 cases a section of cartilage was seen projecting through a tear in the mucosa. The upper lateral cartilages are depressed along with the septum.

In almost all cases reduction of the fracture was carried out by pressure against the nasofrontal processes of the maxilla at the base line of the nose. This method had a tendency to evert the upper edge of the fragments (Metzenbaum).[5] If this maneuver was not successful, a rasp was inserted into the nose and pressure applied outward on the base line, or an Asch septum forceps was employed to rock the bone outward. The rotation of the lower (maxillary) fragment, in turn, freed the upper fragment or fragments for elevation with a rasp. After the nasal bones had been elevated, the maxillary fragments were rotated internally with slight pressure. In a few cases, when the rotation of the lower maxillary fragments inward had been accomplished, they would slip down out of position. This mishap necessitated the eversion of the fragment again and the insertion of petrolatum packing before the rotation of the fragment inward again. The packing prevented the fragment from slipping in and down.

The upper lateral cartilages were almost always elevated at the same time as the nasal bones because of their firm attachment to the bones and also because the cartilages are included in the elevation when elevation is done with the rasp. As the nasal bones and upper lateral cartilage are elevated, the upper fragment of the septal fracture is also elevated. In a few cases the upper fragment of the septum would slip down. In these cases the upper fragment was elevated by the pressure of the rasp on the nasal bones and upper lateral cartilages; at the same time an Asch forceps was used to move the lower fragment back into position, thereby maintaining the upper fragment in place.

5. Metzenbaum, M. F.: Recent Fractures of Nasal Base Lines of Both Outer Nasal Walls, with Divergent Displacement: Orthopedic Procedures for Obtaining Anatomic Reduction of Osseous and Cartilaginous Nasal Framework, Arch. Otolaryng. **34**:723 (Oct.) 1941.

To hold the fragments in position, petrolatum packing was inserted. In a few cases further intranasal support was necessary. Dental wax (Salinger [6]) or strips of dental molding compound were inserted along both sides of the septum, together with petrolatum gauze, to hold the fragments up and act as a splint to keep the septum in the midline. A mattress suture through the two layers of dental wax and the septum is tied over a small piece of rubber tubing. This suture insures the position of the septum. A splint of dental molding compound is applied to the outside and kept in position for six to seven days, along with the intranasal packs.

In 2 cases the procedure described did not suffice to hold the nasal bones and septum in position. Recourse to a head type of appliance was then found necessary. Splints were attached to a headband or head cast with two arms extending down over the nose and two curved extensions fitting into the nose. The curved extensions fitting into the nose are placed under the nasal bones, the object being for them to pull the comminuted fragments up with steady tension. Many such splints have been devised and advocated by Kazanjian,[7] Straith,[8] Erich and Austin,[2] Womack [9] and others. In 1 case this type of immobilization of the nasal bones succeeded in keeping them in position when other means had failed. Wiring over lead plates, as advocated by Brown,[10] was not tried because of the possibility of external scarring.

Recently Hersh [11] and others stated that such appliances were unnecessary. They assert that if there is proper reduction of the fracture intranasal packs serve the same function as the headgear appliances. This contention is substantiated by my experience; of 12 cases of fracture of this type I found the appliance necessary in but 2, and, of these, material aid occurred in only 1 case. In the case in which neither the appliance nor other methods were sufficient to reduce and maintain the bones in proper position, a rhinoplastic procedure was performed at a later date. The rhinoplastic procedure consisted of refracture of the nasal bones and the nasofrontal process of the maxilla, followed by implantation of cartilage.

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6. Salinger, S.: Deviation of Septum in Relation to Twisted Nose, Arch. Otolaryng. **29**:520 (March) 1939.

7. Kazanjian, V. H.: Lateral Pressure Splint for the Nose, Arch. Otolaryng. **27**:474 (April) 1938.

8. Straith, C. L., and DeKleine, E. H.: Modern Management of the Fractured Nose: Collective Review, Internat. Abstr. Surg. **66**:9 (Jan.) 1938; in Surg., Gynec. & Obst., January 1938.

9. Womack, D. R.: A Fracture Device for the Nose, U. S. Nav. M. Bull. **41**:852 (May) 1943.

10. Brown, J. B., in Kernan, J. D.: Surgery of the Nose and Throat, New York, Thos. Nelson & Sons, 1942, p. 256.

11. Hersh, J. H.: Fractures of the Nasal Vault, Ann. Otol., Rhin. & Laryng. **54**:534 (Sept.) 1945.

Laterofrontal Fracture.—Laterofrontal fractures (figs. 5 and 6) occurred in 10 patients.

In this type of fracture there was a combination of lateral and frontal fractures. The nasal bone on the side of the blow was found in one of two positions, the commonest being a slight overriding of the opposite nasal bone and an impingement of the nasal process of the frontal bone on the nasal bone. The nasal bone was also found to be separated from and depressed under its junction with the ascending process of the maxillary bone. In almost half of the fractures there was no overriding of the opposite nasal bone because of the severe depression and locking under the maxilla, so that a space was palpable between the two nasal bones. The opposite nasal bone was always found to be overriding the maxillary bone. In most cases the

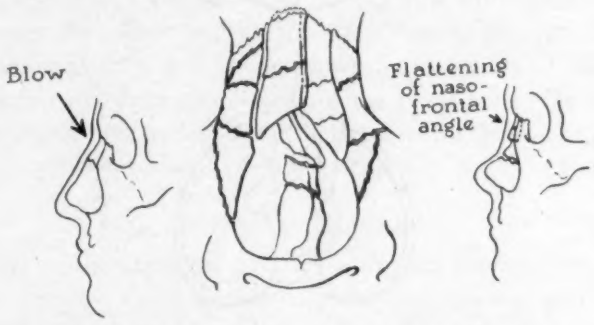

Fig. 5.—Laterofrontal fracture with overriding.

result was comminution of the nasal bones and the ascending processes of the maxilla. Small chip fractures of the lower ends of the nasal bones were also present.

The management of laterofrontal fractures depends on whether the nasal bone on the side of the blow is greatly depressed under the maxillary bone, with a resultant separation of the nasal bones (fig. 6), or whether the nasal bone is not so depressed and is overriding or projecting above the opposite nasal bone (fig. 5). In the former, the treatment is almost identical with that outlined under frontal fractures, while in the latter, the reduction embraces the management of both the lateral and the frontal types of fracture.

When the nasal bone was locked under the nasal process of the frontal bone, it was necessary to further depress the nasal bone, while a Joseph periosteal elevator was engaged under its apex. This procedure unlocks the fragment and allows it to be forced up into position with pressure from the Joseph elevator.

Fracture from Below.—Fracture from below (fig. 7) occurred in 2 cases. The findings were an overriding of the frontal bone and an

Fig. 6.—Laterofrontal fracture with depression.

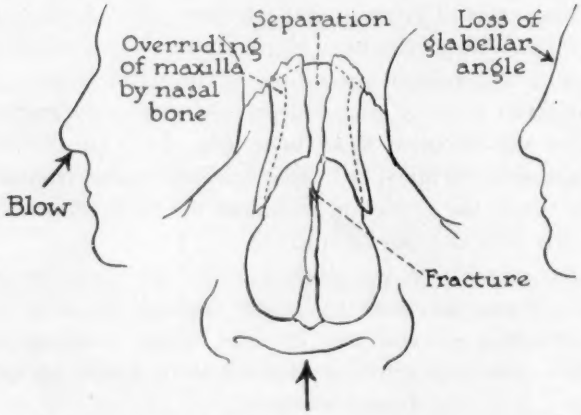

Fig. 7.—Fracture from below.

overriding of the maxillary bones by the nasal bones. There was also a widening of the space between the two nasal bones. The result produced was a wide nose and loss of the glabellar angle.

Reduction of the fracture was accomplished in 1 case simply by elevation of the nasal bones and by pressure from the outside to force them down into position. In the second case, it was necessary to rotate the nasofrontal process of the maxillary bone outward before the nasal bones would fall into position.

Both cases were seen within the first week of the injury. If the injury is seen later, i. e., after two or two and one-half weeks, it may be necessary to use more drastic measures, as the bones are difficult to set into position then. A procedure which has been used is to make an incision between the upper and the lower lateral cartilages, to elevate the periosteum over the nasal bones, and, with the aid of hooks inserted over the upper end of the nasal bones, to exert traction in such a manner as to pull the bones down into position. If this method proves inadequate, the lower border of the nasal bone may be grasped with a hemostat and pulled down along with the hook atop the nasal bone. This procedure was not found necessary in this series of cases.

GENERAL MANAGEMENT

In many of the cases the primary consideration was the control of epistaxis. In most cases the bleeding subsided quickly after intranasal packing and after external pressure. In a few instances the epistaxis was so severe that the packing was left in situ until the bleeding was brought under control so that later there could be proper evaluation and reduction of the fracture.

Ice packs applied to the nose hastened the reduction of edema. It was found better to wait until the edema had subsided sufficiently so that the true extent of the deformity could be studied. In some cases the fracture was reduced early only to have it found, a week later, when the edema had subsided, that there was still deformity which required secondary manipulation of the nasal fragments.

General supportive treatment was usually unnecessary. One patient lost a large amount of blood and required a blood transfusion. When the fracture was compounded externally, and dirt had entered the wound, tetanus antitoxin and antibiotics or chemotherapy were administered.

When the fracture was compounded externally, the treatment was the same as that described under the headings of specific management, except with regard to closure of the wound. In a few cases a bridge of adhesive tape was sufficient to bring the margins of the skin together. In 2 cases the wound extended through the skin, cartilage and mucosa.

The wound is sutured in layers. Mucosal and subcutaneous sutures of 0000 white silk are buried and followed by sutures of 000 black silk for the skin. In 3 cases in which the injury was sustained in automobile (windshield) accidents, a portion of skin from the dorsum or the lateral side of the nose was lost. In each case an immediate graft was sutured into position to prevent scarring and adherence of the scar to the bone and also to act as a protective covering for the nasal bones. Skin taken from the posterior surface of the auricle was found satisfactory as to thickness and color. Whenever a patient presented dirt or gravel in the skin of the nose or face, the skin was scrubbed with a soft brush to remove all dirt or grease. A sterilized soft toothbrush was particularly well suited for this purpose.

After three to seven days, the amount of time depending on the severity of the fracture, the cast and nasal packs are removed. The nasal cavity is carefully aspirated, and, if necessary, adhesive strapping is applied to the nose.

SUMMARY

A series of 100 cases of recent fractures of the nose is analyzed, and the management, mechanics and diagnosis are reviewed. Certain conclusions are drawn from this analysis.

1. Early reduction, within the first few hours, is the procedure of choice. Edema, epistaxis and the general condition of the patient may necessitate waiting. This can safely be done for a few days in children and up to a week in adults.

2. Fractures seen as late as two to three weeks after injury can be reduced; in some cases, in which fibrous instead of bony union occurs, they are reduced as late as five weeks afterward. With an understanding of the mechanics and with the force applied in the proper direction, one may accomplish a reduction at a late date.

3. If it is impossible definitely to ascertain a fracture in children, and there is a reasonable certainty that one exists, exploratory reduction, with the patient under general anesthesia, will usually reveal a fracture.

4. Proper external and internal splinting of the nose is important for the prevention of small hematomas under the cartilages. The absorption of hematomas without pressure will cause perichondritis and fibrous scars, which may subsequently lead to curling of the cartilages, with resultant deviation of the septum and deformity of the alar cartilages.

5. Roentgenologic examination with soft rays is conclusive if the fracture is revealed. In 47 per cent of the cases in the present series the fracture was not definitely visible. Therefore, a roentgenogram showing no abnormalities does not rule out a fracture.

6. As a rule, the nasal fractures in adults are reduced with the use of local anesthesia. Vinyl ether was used for children.

7. Fractures properly reduced are maintained in position by petrolatum gauze packing internally and dental molding compound externally. Once reduced, the fragments will not again become displaced because of these factors: (*a*) swollen mucosa, periosteum and mucoperiosteum; (*b*) no muscular pull on the fragments, and (*c*) adherent overlying periosteum. External headgear appliances were found necessary in 2 cases and proved of value in but 1 case. The petrolatum packing was left in place from three to five days, the amount of time depending on the severity of the fracture. In the severe frontal type of fracture, dental wax was left in position for seven to ten days.

8. All external dirt is removed and scars are cared for as soon as possible.

30 North Michigan Avenue.

Case Reports

STEVENS-JOHNSON DISEASE

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PHILADELPHIA

IN 1922 Stevens and Johnson[1] reported a new symptom complex, occurring in 2 of their patients. Since then, additional cases have been reported, so that this symptom complex now rests on a fairly firm foundation of accurate clinical observations.

The syndrome is variously reported as Stevens-Johnson disease or syndrome or as atypical erythema exudativum multiforme (Hebra) with involvement of the eyes and mucous membranes.

The syndrome[2] consists of the following symptoms:

1. Stomatitis
2. Ophthalmia
3. Cutaneous eruption analogous to erythema exudativum multiforme (Hebra)
4. Fever

It is important for the rhinologist to become acquainted with this syndrome,[3] as he may be the first to see a patient with early symptoms of a badly infected mouth and pharynx which resemble those of severe Vincent's angina or stomatitis caused by a blood dyscrasia. The cutaneous lesions, the ophthalmia and certain complications, such as pneumonia, vulvovaginitis and balanitis, may follow. Relapses are not uncommon.

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1. Stevens, A. M., and Johnson, F. C.: A New Eruptive Fever Associated with Stomatitis and Ophthalmia, Am. J. Dis. Child. **24**:526-533 (Dec.) 1922.

2. Jones, W. Y.; Talbot, F. F., and King, W.: Stevens-Johnson's Disease, Am. J. Ophth. **29**:185-189 (Feb.) 1946. Goldfarb, A. A.: Stevens-Johnson Disease (Erythema Multiforme Bullosa) Treated with Penicillin, J. Pediat. **28**:579-589 (May) 1946. Reed, J. Y.: Stevens-Johnson's Disease in Edentulous Mouth: Report of a Case, Bull. U. S. Army M. Dept. **5**:111-113 (Jan.) 1946. Chick, F. E., and Witzberger, C. M.: Erythema Multiforme Exudativum Accompanying Vincent's Infection, Am. J. Dis. Child. **55**:573-578 (March) 1938. Erger, B. D.: Erythema Multiforme Pluriorificialis (Stevens-Johnson Disease), Mil. Surgeon **95**:308-312 (Oct.) 1944.

3. Howard, J. C., Jr., and Wible, L. E.: Oropharyngeal Manifestations of Erythema Multiforme, Ann. Otol., Rhin. & Laryng. **55**:146-151 (March) 1946.

Hebra [4] in 1866 first described the eruption of the skin known as erythema exudativum multiforme. This is an eruption of macules, papules and vesicles on the dorsal surfaces of the hands and feet. In more severe cases it may be observed on the arms and legs or even on the trunk and face. Hebra further stated that "the complaint terminates spontaneously without leading to evil consequences, and within four weeks at the latest." The cause of the disease was unknown to him. In his cases there were cutaneous lesions only and the disease ran a mild course, with complete recovery.

The type originally described by Stevens and Johnson in 1922, however, often leads to catastrophic consequences, such as blindness. In the 9 cases described by Ginandes [5] (8 others and his own), only 2 patients escaped total loss of vision, and even these 2 became partially blind. The severity of the ocular symptoms must therefore be emphasized. In the 2 cases reported by Stevens and Johnson, 1 child was left with a severe corneal scar and impaired vision in one eye, and panophthalmitis developed in the other, with total loss of vision. Barkan's patient [6] became totally blind because of corneal opacities. Bailey's 3 patients [7] had severe ocular sequelae.

In Stevens-Johnson disease, the mouth and lips become red and swollen. The entire buccal mucous membrane and the lips are covered with a dirty white pseudomembrane, which is friable and appears like a series of ruptured bullae. The hard and soft palate and the tongue are also covered with the pseudomembrane. Where this membrane breaks away from the mucous membrane and the lips the surface appears badly ulcerated and bleeds easily. Because of the extent of the pathologic process in the mouth, the patient may have a certain amount of trismus and can open his mouth only slightly, and this is with great difficulty.

Leukopenia or slight leukocytosis is present, blood cultures are sterile and smears and mouth cultures show only ordinary cocci and bacilli. Evidence of a specific cause is absent, but most of the authors reporting their cases have stated the belief that some systemic infection is the cause of this symptom complex. The marked febrile reaction, the

4. Hebra, F.: On Diseases of the Skin, Including the Exanthemata, translated and edited by C. H. Fagge, London, New Sydenham Society, 1866, vol. 1, pp. 285-289.

5. Ginandes G. J.: Eruptive Fever with Stomatitis and Ophthalmia Atypical Erythema Exudativum Multiforme (Stevens-Johnson), Am. J. Dis. Child. **49**:1148-1160 (May) 1935.

6. Barkan, H.: Herpes Iris of the Conjunctiva, with Report of a Case, Arch. Ophth. **42**:236-240, 1913.

7. Bailey, J. H.: Lesions of Cornea and Conjunctiva in Erythema Exudativum Multiforme (Hebra): Three Cases with Grave Ocular Sequelae, Arch. Ophth. **6**:362-379 (Sept.) 1931.

severe constitutional symptoms and the eruptions on the skin and mucous membranes speak in favor of such a hypothesis.

The involvement of the eyes may be a simple hemorrhagic conjunctivitis, with a purulent exudate, or abscess formation involving part of or all the structures of the globe.

Complications like pneumonia or pseudomembranes on vaginal or urethral walls similar to the lesions in the mouth may develop.

REPORT OF A CASE

J. M. O., a 27 year old married Negro woman, was admitted to my otolaryngologic service at the Philadelphia General Hospital on Sept. 29, 1946. Her chief complaint was a "sore mouth." The patient stated that this started with a "fever blister" on the lip five days before her admission to the hospital. On the day of admission her mouth was so sore and swollen that she could swallow liquids only with a great deal of difficulty. Her past history was noncontributory, except for the drainage of an abscessed tooth in 1942. Her family history was irrelevant.

Physical examination showed a well developed woman who was acutely ill. The temperature was 103 F., the pulse rate 95, the respiratory rate 23 and the blood pressure 120 systolic and 70 diastolic. The oral mucosa, gums and tongue were edematous and covered with a dirty white pseudomembrane. Where the exudate had been removed there were red, bleeding areas. The lips were cracked, markedly swollen, protruded, partially covered with an exudate and constantly oozing blood. A few carious teeth were visible, but it was not until two weeks later that a thorough examination of the gums, teeth and pharynx could be made. The corners of the lips were split, and the patient had a pronounced degree of trismus.

My first diagnostic impression was that the patient had Vincent's angina. This diagnosis was dispelled by the laboratory data, and only on one or two occasions were a few Vincent's organisms demonstrated. Repeated mouth smears and cultures in the next few days showed the organisms as Hemophilus influenzae, Staphylococcus aureus and Staphylococcus albus, paracolon bacillus, diphtheroid bacillus, Streptococcus viridans and occasional Vincent's organisms. The white blood cell count was 27,350 and the red blood cell count 4,020,000, on the day after admission.

The patient was given sulfadiazine for twenty-four hours, and a maculopapular eruption then developed all over her body. The lesions were 0.5 to 1 cm. in diameter. A tiny vesicle then developed in the center of each maculopapule. Later these lesions dried and were replaced by an area of pigmentation with an inflamed area around it. The vesicular part then desquamated.

The dermatologic consultant made a diagnosis of erythema exudativum multiforme and the medical consultant a diagnosis of sulfonamide rash. About three days later, hemorrhagic conjunctivitis developed in both eyes, with purulent exudate. The medical consultant was again called in and, with the four cardinal symptoms of fever, stomatitis, conjunctivitis and characteristic eruption of the skin, made a diagnosis of Stevens-Johnson disease.

When the cutaneous eruption first developed, the use of sulfadiazine was discontinued and was replaced with administration of penicillin, 300,000 units

daily, parenterally. Progress was slow. Clysis was performed repeatedly, and the eyes were treated with penicillin locally. The temperature remained elevated.

One week after admission, atypical pneumonia developed, with pleural effusion in the base of the left lung. The temperature was 105 F. At the same time vaginitis developed, with the same type of membrane as was present in the mouth. Small blood transfusions were administered, the patient was put in an oxygen tent, and administration of penicillin was continued.

She made an uneventful recovery thereafter. Progress was slow but steady. Roentgen therapy was applied to her lips and was effective. During her illness, the red blood cell count varied from 4,020,000 to 2,250,000. The white blood cell count varied from 27,350 on admission to 6,900. The only high white blood cell count was the 27,350 on admission. All others were low.

About two weeks after her admission to the hospital, the first complete examination of the mouth was made. The trismus had cleared up, and the patient was able to open her mouth with a fair degree of comfort.

The unusual finding was that of thirty teeth in her mouth, seventeen had carious crowns, and there were thirteen carious fangs with no crowns. Not a healthy tooth in her mouth! Smears and cultures from the teeth showed the same organisms as were found in smears and cultures from the mucous membranes of her mouth.

One month after her admission she was discharged as cured. She left the hospital with good vision, scarred corners of her lips, pigmented blotches on her skin and with all her carious teeth. She promised to have her own dentist extract all her teeth, after having refused our offer of dental care at the hospital.

Six weeks later she was readmitted to the hospital with a relapse. The temperature was 104 F. The lips were covered with thick layers of dried blood, and membranous stomatitis, foul breath and sore throat were present. Again trismus was present, and she ate and talked with difficulty. Cutaneous lesions developed as on the first admission. She still had all her carious teeth and, as she improved, again refused extraction at the hospital. Ten days after this admission she was discharged in fairly good condition.

Within the next six months she was admitted three times to another hospital, with the same symptoms as before. She still retained her infected teeth.

As late as one year after her first admission she had no dental work done and was also four months pregnant, and again had a mild relapse. She telephoned me and explained her condition but refused to return to my hospital service, as I insisted on the extraction of all her teeth.

ETIOLOGIC CONSIDERATIONS

It would appear, from this case as well as from others reported since Stevens and Johnson first described their 2 cases, that the four cardinal symptoms described are due to some infectious process in the body.

In my case it would seem that the infection of thirty carious teeth and fangs could easily have been the cause of all the symptoms. The fact that my patient retained these teeth and then had four relapses would add to my hypothesis of infection.

DIFFERENTIAL DIAGNOSIS

The syndrome is characteristic. In the early stages the disease may be mistaken for Vincent's angina, stomatitis from a blood dyscrasia as in severe leukemia or a simple multiforme erythema as described originally by Hebra. However, as the disease advances day by day Vincent's organisms cannot be demonstrated in sufficient numbers to classify it as definite Vincent's angina. Cutaneous lesions and ophthalmia are not seen in cases of Vincent's infection. The blood picture eliminates blood dyscrasias. Hebra's patients with erythema exudativum multiforme were afebrile, with no ocular symptoms or stomatitis. Until a specific etiologic factor is found to explain this condition, investigators will be divided into two classes: (*a*) those who think that the symptoms described by Stevens and Johnson are a new entity and (*b*) those who prefer to consider the condition as a rare manifestation of a known entity—erythema exudativum multiforme (Hebra).

THERAPY

No definite therapy is established for these cases. I found that administration of penicillin, 300,000 units daily parenterally, was effective, and I advise that it be continued for several days after most of the symptoms subside.

Penicillin applied locally to eyes and lips is also helpful. Roentgen therapy helps clear up the cracks and excoriations of the lips.

SUMMARY

A case is reported which presented the four bizarre symptoms first described by Stevens and Johnson, in 1922: (1) stomatitis, (2) ophthalmia, (3) cutaneous eruption like erythema exudativum multiforme and (4) fever.

The condition was probably infectious in origin, and thirty carious teeth may have been responsible for the systemic intoxication.

There were four relapses, and the patient still has her carious teeth.

This patient, fortunately, still has good vision. Others have lost theirs partially or completely.

6330 Lebanon Avenue.

Special Reports

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Acousticon Model A-100 Mfr. Dictograph Products Corporation 580 Fifth Avenue New York 19	J. A. M. A. **138:** 293 (Sept. 25) 1948.
Aurex (Semi-Portable)	J. A. M. A. **109:** 585 (Aug. 21) 1937.
Aurex Model C-B and Model C-A	J. A. M. A. **120:** 535 (Oct. 17) 1942.
Aurex Model F	J. A. M. A. **138:** 294 (Sept. 25) 1948.
Aurex Model H Mfr. Aurex Corporation 1117 North Franklin Street Chicago	J. A. M. A. **136:** 1099 (April 24) 1948.
Beltone Mono-Pac	J. A. M. A. **130:** 637 (March 9) 1946.
Beltone Harmony Mono-Pac Mfr. Beltone Hearing Aid Company 1450 West Nineteenth Street Chicago	J. A. M. A. **133:** 543 (Feb. 22) 1947.
Dysonic Model 1 Mfr. Dynamic Hearing Aids, Inc. 1042 Atlantic Avenue Brooklyn 16	J. A. M. A. **137:** 1534 (Aug. 21) 1948.
Electroear Model C Mfr. American Earphone Company, Inc. 10 East Forty-Third Street New York 17	J. A. M. A. **136:** 769 (March 13) 1948.
Gem Hearing Aid Model V-35 Mfr. Gem Ear Phone Company, Inc. 50 West Twenty-Ninth Street New York 1	J. A. M. A. **139:** 229 (Jan. 22) 1949.

Maico Type K	J. A. M. A. **129:** 32 (Sept. 1) 1945.
Maico Atomeer	J. A. M. A. **133:** 542 (Feb. 22) 1947.
Mfr. The Maico Company, Inc. North Third Street Minneapolis	
Mears Aurophone Model 200	J. A. M. A. **138:** 428 (Oct. 9) 1948.
1947-Mears Aurophone Model 98	J. A. M. A. **137:** 1535 (Aug. 21) 1948.
Mfr. Mears Radio Hearing Device Corporation 1 West Thirty-Fourth Street New York 1,	
Micronic Model 101 (Magnetic Receiver)	J. A. M. A. **139:** 99 (Jan. 8) 1949.
Mfr. Micronic Company 727 Atlantic Avenue Boston 11	
Microtone T-3 Audiomatic	J. A. M. A. **138:** 1229 (Dec. 25) 1948.
Microtone T-4 Audiomatic	J. A. M. A. **136:** 109 (Jan. 10) 1948.
Microtone T-5 Audiomatic	J. A. M. A. **139:** 379 (Feb. 5) 1949.
Mfr. The Microtone Company 4602 Nicollet Avenue Minneapolis 9	
National Cub Model	J. A. M. A. **138:** 295 (Sept. 25) 1948.
National Standard Model	J. A. M. A. **138:** 295 (Sept. 25) 1948.
National Star Model	J. A. M. A. **138:** 295 (Sept. 25) 1948.
Mfr. National Hearing Aid Laboratories 815 South Hill Street Los Angeles 14	
Otarion, Model A-1	J. A. M. A. **115:** 1101 (Sept. 28) 1940
Otarion, Model A-3	J. A. M. A. **132:** 1071 (Dec. 28) 1946.
Otarion, Models A-4 J & S	J. A. M. A. **132:** 925 (Dec. 14) 1946.
Otarion, Model E-1	J. A. M. A. **136:** 108 (Jan. 10) 1948.
Otarion, Model E-1S	J. A. M. A. **138:** 650 (Oct. 30) 1948.
Otarion, Model E-2	J. A. M. A. **138:** 887 (Nov. 20) 1948.
Mfr. Otarion Hearing Aids 159 North Dearborn Street Chicago	
Paravox Models VH and VL	J. A. M. A. **132:** 79 (Sept. 14) 1946.

Paravox Model XT	J. A. M. A. **134:** 365 (May 24) 1947.
Paravox Model XTS Mfr. Paravox, Inc. 2056 East Fourth Street Cleveland 15	J. A. M. A. **136:** 109 (Jan. 10) 1948.
Precision Table Hearing Aid Mfr. Precision Electronics Company 850 West Oakdale Avenue Chicago 14	Report not yet published.
Radioear Model 45-CM	J. A. M. A. **126:** 1151 (Dec. 30) 1944.
Radioear Model 45-M-magnetic air conduction receiver	J. A. M. A. **127:** 219 (Jan. 27) 1945.
Radioear Model 45-M-magnetic bone conduction receiver	J. A. M. A. **127:** 27 (Jan. 6) 1945.
Radioear Permo-Magnetic Uniphone Mfr. E. A. Myers & Sons 306 Beverly Road Mount Lebanon Pittsburgh	Report not yet published.
Ravox (Semi-Portable) Mfr. Zenith Radio Corporation 6001 West Dickens Avenue Chicago	J. A. M. A. **113:** 18 (Oct. 28) 1939.
Silver Micronic Hearing Aid, Model 101	J. A. M. A. **135:** 159 (Sept. 20) 1947.
Silver Micronic Hearing Aids, Models 202M and 202C Mfr. Micronic Company 727 Atlantic Avenue Boston 11	Report not yet published.
Solopak Hearing Aids Mfr. Allen-Howe Electronics Corporation Salem, Mass.	J. A. M. A. **136:** 768 (March 13) 1948.
Sonotone Audicles Nos. 530, 531 and 533	J. A. M. A. **123:** 837 (Nov. 27) 1943.
Sonotone Model 600	J. A. M. A. **131:** 523 (June 8) 1946.
Sonotone Model 700	J. A. M. A. **135:** 838 (Nov. 29) 1947.

Sonotone Model 900 Mfr. Sonotone Corporation Elmsford, N. Y.	Report not yet published.
Superfonic Hearing Aid Mfr. American Sound Products, Inc. 2454 South Michigan Avenue Chicago	J. A. M. A. **138:** 293 (Sept. 25) 1948.
Telex Model 22	J. A. M. A. **134:** 605 (June 14) 1947.
Telex Model 97	J. A. M. A. **138:** 294 (Sept. 25) 1948.
Telex Model 612	J. A. M. A. **114:** 1634 (April 27) 1940.
Telex Model 900	J. A. M. A. **117:** 1978 (Dec. 6) 1941.
Telex Model 1020	J. A. M. A. **117:** 2072 (Dec. 13) 1941.
Telex Model 1550 Mfr. Telex, Inc. Minneapolis 1	J. A. M. A. **126:** 705 (Nov. 11) 1944.
Tonemaster Model Royal Mfr. Tonemasters, Inc. 1627 Pacific Avenue Dallas 1, Texas	Report not yet published.
Trimm Vacuum Tube Model 300 Mfr. Trimm, Inc. 400 West Lake Street Libertyville, Ill.	J. A. M. A. **133:** 542 (Feb. 22) 1947.
Unex Model "A" Mfr. Nichols & Clark Hathorne, Mass.	J. A. M. A. **134:** 254 (May 17) 1947.
Vactuphone Model 3 Mfr. Allen-Howe Electronics Corporation Salem, Mass.	J. A. M. A. **136:** 769 (March 13) 1948.
Western Electric Ortho-tronic Model	J. A. M. A. **121:** 1283 (April 17) 1943.
Western Electric Model 63	J. A. M. A. **131:** 895 (July 13) 1946.
Western Electric Model 64	J. A. M. A. **134:** 605 (June 14) 1947.
Western Electric Models 65 & 66 Mfr. Western Electric Company, Inc. 120 Broadway New York 5	J. A. M. A. **137:** 534 (June 5) 1948.

Zenith Radionic Model A-2-A	J. A. M. A. **127:** 159 (Jan. 20) 1945.
Zenith Radionic Model A-3-A	J. A. M. A. **127:** 159 (Jan. 20) 1945.
Zenith Radionic Model B-3-A	J. A. M. A. **127:** 158 (Jan. 20) 1945.
Zenith Model 75 Mfr. Zenith Radio Corporation 6001 Dickens Avenue Chicago	J. A. M. A. **135:** 773 (Nov. 22) 1947.

All of the accepted hearing devices employ vacuum tubes.

AUDIOMETERS ACCEPTED

ADC Audiometer Model 50 Mfr. Audio Development Company 2833-13th Avenue South Minneapolis	J. A. M. A. **137:** 1131 (July 24) 1948.
Maico Audiometer Model D-5	J. A. M. A. **114:** 139 (Jan. 13) 1940.
Maico Audiometer Model D-8	J. A. M. A. **120:** 205 (Sept. 19) 1942.
Maico Audiometer Model D-9	J. A. M. A. **138:** 428 (Oct. 9) 1948.
Maico Model RS Group Phonographic Audiometer Mfr. The Maico Company, Inc. North Third Street Minneapolis	J. A. M. A. **137:** 1535 (Aug. 21) 1948.
Sonotone Audiometer, Model 20	J. A. M. A. **124:** 94 (Jan. 8) 1944.
Sonotone Audiometer, Model 21 Mfr. Sonotone Corporation Elmsford, N. Y.	Report not yet published.
Western Electric Audiometer, Model 4C	J. A. M. A. **118:** 1297 (April 11) 1942.
Western Electric Audiometer, Model 4CA	J. A. M. A. **139:** 99 (Jan. 8) 1949.
Western Electric Audiometer, Model 6 BP Mfr. Western Electric Company, Inc. 120 Broadway New York 5	J. A. M. A. **114:** 1634 (April 27) 1940.

Abstracts from Current Literature

Ear

NEUROPHYSIOLOGICAL CLUES TO AUDITORY ACUITY. LEO G. DOERFLER, J. Speech & Hearing Disorders **13**:227, 1948.

The author describes an attempt to utilize the galvanic skin responses as neurophysiologic clues to auditory acuity. The equipment records the Tarchanoff effect, or the actual electromotive force which is generated between two electrodes, presumably by the action of the sweat glands. The procedure necessarily varied from subject to subject. Some were instructed to respond by pressing a telegraph key when they heard a tone. It had previously been found that such an action did not produce a galvanic skin response. Others were told that they would hear tones of varying frequency and intensity but that they were to do nothing. In many there appeared the complicating factor of adaptation. The subject would give a good response to the first few stimuli, and then repeated stimulation would elicit no reliable response. Subjects also varied tremendously in their responses, some responding perfectly down to their thresholds of sensitivity as measured by audiograms, while others often gave no consistent response, even at intensities well above threshold. Adaptation appeared to be overcome to a large extent through the use of an ascending, rather than a descending, intensity technic. The second problem of variation in subjects was difficult, but a warning device of a small flashlight helped in producing the galvanic skin response. The most satisfactory results were obtained by telling the subject that the auditory stimulus would be presented sometime within a period of eight seconds after the light went out. All subjects of the experiment had substantially normal hearing, except one, who had a dip of 4,096 cycles. There is some belief, based on research at Deshon General Hospital, that emotionally charged speech material may result in a more reliable galvanic skin response, but the evidence is meager. The galvanic skin response offers a promising means of ascertaining auditory acuity.

PALMER, Wichita, Kan.

PREVENTION OF DEAFNESS BY THE ELIMINATION OF HYPERTROPHIED LYMPHOID TISSUE IN THE NASOPHARYNX BY RADIUM THERAPY. J. COLEMAN SCAL, New York State J. Med. **48**:2715 (Dec. 15) 1948.

From the department of otolaryngology of the Jewish Memorial Hospital, Scal reports 5 typical cases from a series. All the patients were 8 years of age except a boy of 7. Scal points out that radium was used at first only in treatment of malignant growths. It is now useful for benign conditions, particularly lymphoid hypertrophy in the nasopharynx. Use of radium is superior to that of roentgen radiation because one must use a greater dose of the latter and intervening tissue is likely to be affected. The alpha rays can be screened out of a radium applicator by using the Monel metal tubes, 15 mm. long and 3 mm. thick, which contain 50 mg. of radium sulfate. The author admits some danger from overdosage but attributes this to a too frequent change of physicians, so that the operator does not know what his predecessor has done. Scal cites

Crowe's twenty years of experience without any harmful results, as well as the work of E. P. Fowler Jr. during World War II, in treatment of aerotitis associated with pathologic changes at the introitus of the eustachian tube. Once the tube was cleared by radium, the pilots were soon flying again and "had no further trouble with disturbance of air pressure." The method of procedure is well known and need not be repeated here. Recently Scal has used radium in treatment of children with asthma and allergic bronchitis. Results have not been favorable as yet, but the elapsed time has been insufficient. Scal concludes that irradiation therapy is not a treatment for deafness but for elimination of conditions that may cause deafness."

Abstracter's Comment.—Some rhinologists are not yet convinced of the necessity of using radium to destroy lymphoid tissue in the fossae of Rosenmüller. In children, one can crush the lateral masses and break down adhesions with an index finger. Some at least of these obstructions are leftovers from an incomplete adenoidectomy. This operation is still one of the most unsatisfactory in nasal surgery because one works without seeing what one is doing. Too vigorous use of an instrument may remove the eustachian eminence, and stripping of the anterior wall of the nasopharynx is common. Some surgeons avoid this by taking out the central mass only, but in most hospitals it is the rule to go in later with the index finger and feel for tissue which should be removed. Now and then one finds a child consigned to a class for the deaf who can be promptly returned to a normal class after this "finger operation." Results are immediate and seemingly permanent. The method may not work so well in adults, but there can be no harm in trying it, leaving to time the question of later application of radium. Since one is cautioned to use radium not more than three or four times over a period of eight weeks, and to wait for six months for decision as to further irradiation, the choice of the finger procedure seems inevitable as a precursor, at least, of radioactivation.

VOORHEES, New York.

Larynx

ESOPHAGEAL INTUBATION FOR REPAIR OF PHARYNGO-ESOPHAGEAL DIVERTICULUM. RICHARD N. TERRY, New York State J. Med. **48**:1709 (Aug. 1) 1948.

Terry states that about 98 per cent of all diverticula of the esophagus occur at the "weak point" in the posterior wall at the junction of the inferior constrictor and the cricopharyngeus muscle. Like other hernias, esophageal diverticula occur in an area which cannot accommodate itself to a certain, sudden stress. Once a small sac has formed, it grows larger from the weight of food and drink, angulates downward and displaces the esophagus to the left.

Surgical repair is difficult, since one is obliged, as it were, to take a reef in a collapsed sail. It is hard to find the defect and hard to keep it under the eye and hand, once found. A tube in the pharynx directed anteriorly and to the right would by-pass the pouch; but, directed posteriorly and to the left, it will enter the diverticulum. The technic used in 2 cases is described. Lahey used regional block anesthesia in 118 cases but discarded it as "unsatisfactory." His present procedure is not outlined. Complications are temporary or permanent laryngeal paralysis, recurrence, fistula and leakage through the seam.

By esophageal intubation, it is hoped that postoperative complications can largely be eliminated. Thus positive identification of the sac is made, coaptation of cut edges is better obtained and "anatomic closure" is thus favored.

This work was done in the Buffalo General Hospital, and the report was read before the section on anesthesiology at the annual meeting of the New York State Medical Society, New York, May 19, 1948.

VOORHEES, New York.

ANESTHESIA IN THORACIC SURGERY WITH ESPECIAL REFERENCE TO SURGERY OF THE ESOPHAGUS. SYDNEY S. LYONS, New York State J. Med. **48**:1943 (Sept 1) 1948.

Lyons is an anesthetist working in the Mount Sinai Hospital. There were 224 consecutive cases of cancer of the esophagus, some of which required anastomoses above, and some below, the aorta. The factors to be considered in regard to anesthesia fall into respiratory, circulatory and reflex groups. Intratracheal intubation is stressed as of high importance in administration of the anesthetic, nitrous oxide, ethylene or cyclopropane followed by ether. The new term "compensated breathing" means to supervise the exchange of gases at each inspiration by maintaining a pressure of 8 to 10 cm. of water in the rebreathing bag; this is done to maintain the respiratory balance. While freeing an adherent mass, the surgeon may enter the opposite pleural cavity. The alert anesthetist will note this at once and take measures to maintain the "vital capacity." However, Lyons states that survival is "practically impossible," but death on the table does not occur, for adequate ventilation of the lungs can be carried on until the patient can be taken to his room. Air tight closure of the chest is difficult to accomplish but must be tried. Inhalation of nitrogen or helium from sixteen to eighteen minutes may help. Slight overexpansion of the lungs is imperative until the wound is closed. This was maintained in the last 23 cases, and there was no respiratory embarrassment or complications. Preliminary medication before operation is kept to a minimum in order that the threshold of the respiratory center may not be elevated.

VOORHEES, New York.

Nose

RHINOLOGY IN CHILDREN: RÉSUMÉ OF AND COMMENTS ON THE LITERATURE FOR 1947. D. E. S. WISHART, Laryngoscope **58**:897 (Sept.) 1948.

In this article, under the heading "General Articles on Rhinology and Accessory Sinus Disease," Wishart emphasizes Alvarez' paper on psychosomatic medicine.

Unless there is a vitamin deficiency or need, there is no satisfactory evidence that vitamin supplements have any prophylactic value against the common cold. However, babies and children, whose requirements are greater than those of adults, should be given preparations of vitamins A, C and D to insure resistance to infection. Injections of vaccines containing influenza virus A and B have given encouraging results in controlled trials. Milk-borne epidemics of typhoid can be prevented by pasteurization of milk. The use of liquid petrolatum U. S. P. in food prevents substantial amounts of food carotene from entering the body; when taken for constipation, some of it passes through the intestinal wall and into the liver. This raises the question whether it can with safety be taken regularly, as it is by some persons.

For treatment of maxillary sinusitis, an indwelling rubber catheter of the de Pezzer type has given good results; irrigations through it were made two and three times a day for seven to ten days. Penicillin administered by mouth, hypodermic injection, spray, mist or antral irrigation is often of little value in sinusitis.

However, penicillin is most valuable in cases in which the infection has extended beyond the sinus, e. g., in cases of orbital cellulitis.

Under the heading "Diagnosis of Sinus Disease," Wishart notes that roentgenographic methods add little to the diagnosis of acute conditions. The use of iodized oil U. S. P. is helpful, both in the interpretation of changes in soft tissue and in the determination of the emptying time of the sinus, a diagnostic point often overlooked.

Allergy is often effectively combated by antihistamine drugs. Some persons with asthma are benefited by the use of radium in the nasopharynx. The local use of the sulfonamide drugs and of penicillin is advised against because of the sensitization they produce, which may prevent its systemic use later when it may be more urgently needed.

Under "Hemorrhage," Wishart discusses pharyngeal abscess with erosion of the carotid artery. In cases of epistaxis, it should be remembered that both the external carotid artery and the circle of Willis supply blood to the nose, the former below the middle turbinate body, the latter above.

Under the heading "Tonsils and Adenoids," the author discusses Kleinert's paper on preoperative medication; barbiturates and scopolamine increase the danger of anesthesia, and their use is advised against.

The effects of irradiation of the nasopharynx have been to reduce lymphoid tissue and to prevent recurrence by the destruction of the germinal centers. Hearing, as well as otitis media and infections of the upper respiratory tract, were benefited in many cases by radiation therapy, in addition to surgical treatment when indicated.

The relation of poliomyelitis to tonsillectomy is controversial until more is known; considering the attitude of the public, it is probably better not to operate during the season of poliomyelitis.

Tracheotomy is an important adjunct to the treatment of bulbar poliomyelitis, according to some investigators. The criteria, however, are still not clear.

Under the heading of "Surgery," Wishart states that Goodyear advocates a trephine opening to relieve the pain of acute fulminating sinusitis.

The author concludes with a discussion on new growths and presents an interesting case of myiasis, a disease caused by maggots or flies.

HITSCHLER, Philadelphia.

Miscellaneous

INHALATION OF PENICILLIN DUST. L. KRASNO, M. KARP and P. S. RHOADS, J. A. M. A. **138**:344 (Oct. 2) 1948.

The authors describe a simple apparatus for delivering nonirritating penicillin dust to the respiratory tract and include several illustrations of the apparatus. The method is outlined in detail, accompanied with several tables giving the bacteriologic data obtained from cultures of the throat, nose and sputum prior to and after completion of the course of inhalation therapy.

From one to three times a day, 357 patients were treated with the inhalation of 100,000 units of penicillin dust. Treatments at the office were supplemented at home. The home treatments were especially used in cases of bronchiectasis. Cultures from the throat, nose and sputum showed, in many instances, a decided diminution of gram-positive bacteria and some diminution of gram-negative organisms.

The penicillin levels of the blood indicated absorption from the respiratory tract. Maximum levels in the blood were obtained one hour after inhalation; therapeutic levels were maintained for five hours after inhalation. Three to 6 per

cent of the patients were allergic to the drug; no ill effects were observed on the patients with a more serious involvement. Though this method has given some favorable results, the authors wisely conclude that it cannot be relied on as the sole treatment for these infections "to the exclusion of intramuscular or intravenous administration of penicillin, attention to allergic sensitivity, local drainage of sinuses and bronchiectatic cavities and the like."

GORDON, Philadelphia.

POTENTIALITIES AND LIMITATIONS OF CORRECTIVE RHINOPLASTY. LEROY S. SAFIAN, New York State J. Med. **48**:2160 (Oct. 1) 1948.

Writing from the Hospital for Joint Diseases, Safian discusses the prognostic criteria governing successful end results in corrective rhinoplasty. He advocates careful selection of patients. Results of plastic surgery are not always good because of excessive cicatricial tissue, adhesions, unresolved hematomas, periosteal proliferation and graft absorption. A surgeon satisfied with the result may have a patient who is not, and vice versa, the psychology of the situation often being peculiar. Men are more easily satisfied than women, and persons in the theatrical field are the most appreciative. It is better that a patient request an operation of his own will than that he be forced into it by well meaning friends. A thorough understanding should be had with the patient before the operation; the difficult or unreasonable person should not be accepted. The anesthesia to be used, the probable resultant discomfort and the length of time to be sacrificed from normal activities should be told to the patient beforehand.

Moderate deviation of the septum may not always call for resection before, during or after plastic surgery. The condition of the skin—acne rosacea; rhinophyma; large-pored, oily skin, and eczema—may present definite limitations to postoperative healing. Previous roentgen irradiation may delay healing. The age at operation varies, but in general a person who has attained maturity is preferable to one of an age when ossific centers of growth are still active. If operation is imperative in the preadult, the possible need for further operation later on should be explained. An otherwise excellent surgical result may lead to incrimination, bitterness, even legal action, on the part of a psychoneurotic patient. Safian's summary of the entire problem of corrective surgery is one of the best.

VOORHEES, New York.

Book Reviews

Morell Mackenzie: The Story of a Victorian Tragedy. By R. Scott Stevenson, M.D., F.R.C.S., Edin. Price, $5. Pp. 194, with 18 illustrations. New York: Henry Schuman, Inc. 1947.

The reviewer's interest in the story so brilliantly related by Dr. Stevenson was first aroused when sitting with the late Dr. J. Solis-Cohen, of Philadelphia, at a dinner of the Philadelphia Laryngological Society. Dr. Solis-Cohen was a contemporary of Dr. Morell Mackenzie, had studied with him in London, had known him well and had followed the fatal illness of the Crown Prince Frederick with the greatest professional interest. Several years later, the late Dr. D. Bryson Delavan, of New York, who had also known Mackenzie well, told the reviewer many details of the great controversy that shook both the British and the German laryngologic profession, created much international bitterness and practically ruined Mackenzie's reputation as the greatest laryngologist in the world. It was at this time, so many years after the loss of her husband, that the letters of the Empress Frederick were published, which made intensely interesting reading to any laryngologist.

Every laryngologist should be interested in the history of his subject, and this splendidly written book on the Mackenzie controversy should be in every laryngologist's library. Dr. Stevenson has painstakingly searched for all information available and has produced a complete, fascinating and readable story, which necessarily covers much of the pioneer work in laryngology, not only of Britain, but of other countries, notably Germany, as well.

It is, of course, futile to speculate on what might have happened if Frederick, the Crown Prince, had not become emperor, which title he held for such a short time—in fact, only long enough to pass the succession on to his son, Wilhelm. If it had turned out otherwise, might World War I have been avoided? Who knows?

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Place: London. Time: July 18-23, 1949.

Second Pan-American Congress of Oto-Rhino-Laryngology and Bronchoesophagology

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Place: Montevideo. Time: January 1950.

NATIONAL

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American Broncho-Esophagological Association

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Place: Drake Hotel, Chicago. Time: April 18-20, 1949.

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